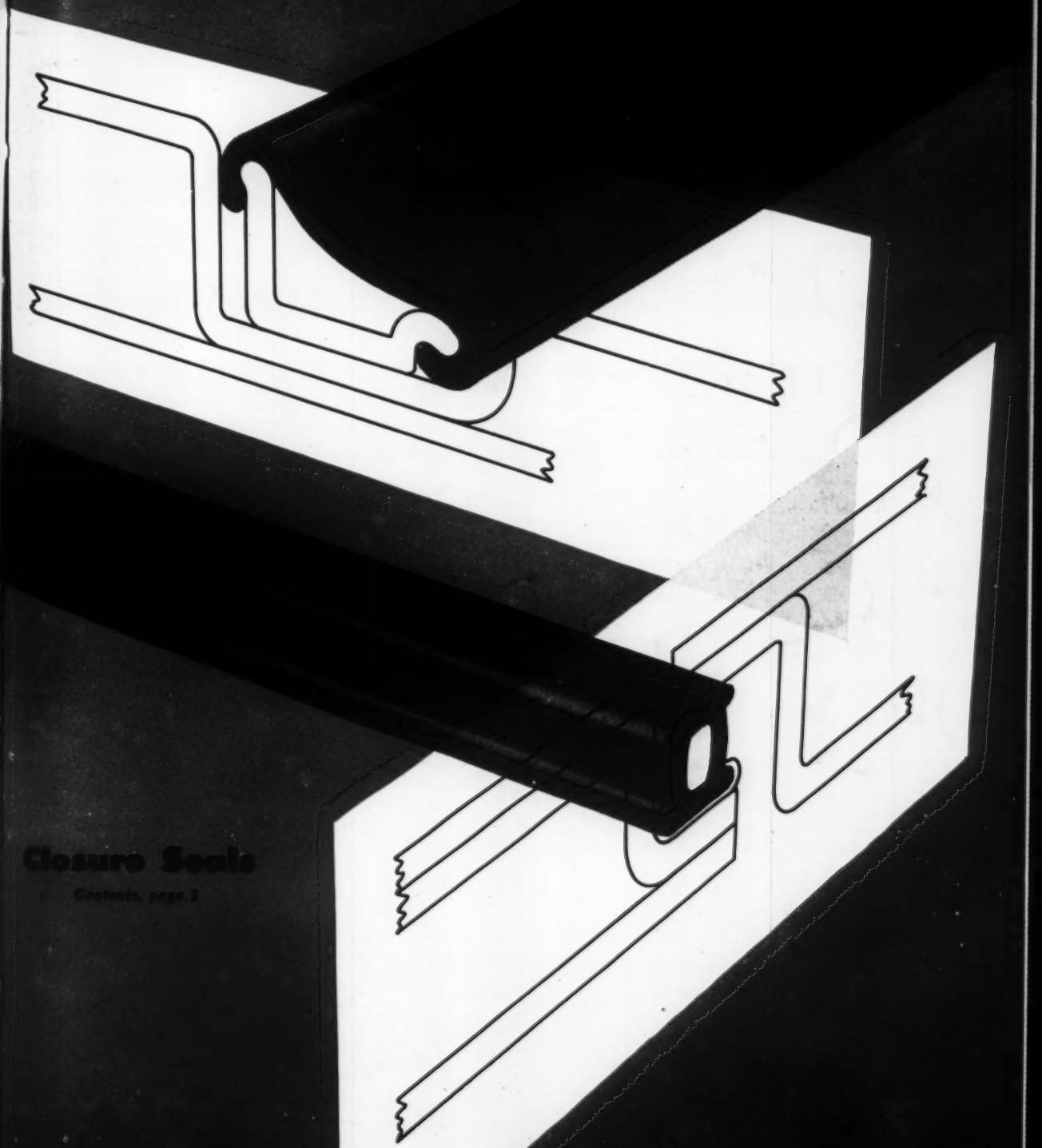
621
MACHINE DESIGN
A PENTON PUBLICATION



Closure Seals

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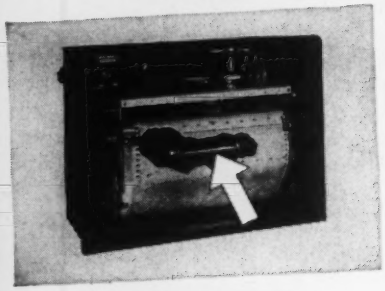
FLEXIBLE SHAFT IDEAS for ENGINEERS

Flexible Shafts simplify manufacturing operations — lead to improved designs

Cost-savings possibilities are many when you design with these useful mechanical elements

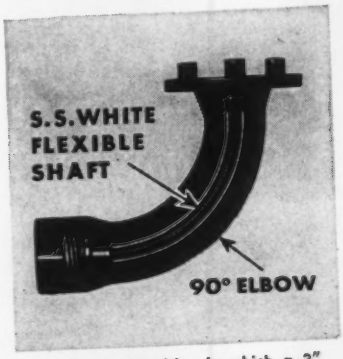


Giving alignment problems the "go-by"

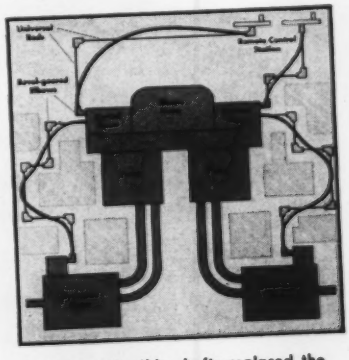
NOT ONLY DOES a flexible shaft provide a vibrationless drive in this sensitive recording pyrometer, but it eliminates the need for accurate alignment of the connected spindles. The ability of a flexible shaft to operate under conditions of misalignment is a feature that is of extreme importance in many remote control and power drive installations.

Here is a bulletin every designer should have

Bulletin 5601 contains the latest information on flexible shafts. Included are full details on how to select and apply power drive and remote control flexible shafts as well as up-to-date tables showing flexible shaft sizes and characteristics. Send for a copy.



A truck recorder drive in which a 3" flexible shaft replaced a set of bevel gears and straight shafts. Result: fewer parts, lower cost and elimination of failures caused by high starting torque of the gears.



4 standard flexible shafts replaced the 35 parts formerly used to control this dual hydraulic power unit. Result: a 90% cost savings and 100% improved performance.

NO OTHER SINGLE MECHANICAL ELEMENT solves power drive and remote control problems as simply and economically as an S.S.White flexible shaft.

Savings through Simplification

For instance, the ability of an S.S.White flexible shaft to operate around turns and under conditions of misalignment is a big help in simplifying drive or control setups. It means that a single flexible shaft can often be used in place of whole systems of bevel and worm gears, solid shafts, universals, etc. Naturally, with fewer parts to handle, production time and costs can be trimmed.

Improved Designs

Simplification is not the only advantage offered by an S.S.White flexible shaft. It gives greater leeway in locating coupled parts to insure greater efficiency, easier operation, greater compactness, or more attractive appearance.

Reduced Layout Time

Not the least of a flexible shaft's advantages, is the ease with which it can be applied. There are no gear ratios to work out—no alignment problems—no worries about tolerances on bearing and journal fits, about special machining, etc. And, the wide range of physical characteristics and sizes available, make it easy to meet a diversity of requirements.

F6-4

FIRST NAME IN FLEXIBLE SHAFTS

S.S.White

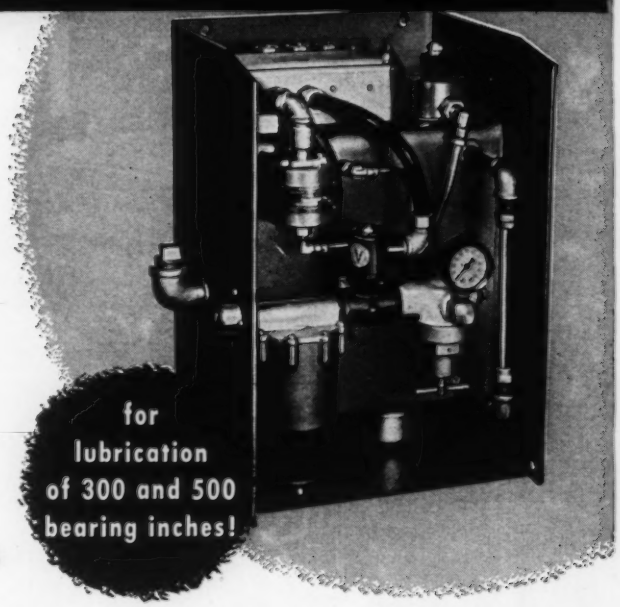
S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Circle 501 on page 19

Now! Design Automatic Lubrication into your largest machines!

2 new ALEMITE OIL-MIST AUTOMATIC LUBRICATION MODELS



Greater capacity . . . greater coverage . . . greater savings! Now the largest machines can have moneysaving, timesaving Alemite Oil-Mist Automatic Lubrication! These two new models offer greater capacity for lubricating up to 300 and 500 bearing inches! They are the same type of famous Alemite Oil-Mist systems already proved on countless machines in all types of industry.

Alemite Oil-Mist Lubricators atomize oil into mist and distribute it through tubing to all types of lubricated mechanisms—anti-friction and plain bearings, gears, slides, ways, chains, cams, and rollers. Amazingly simple, continuous and fully automatic . . . Alemite Oil-Mist eliminates the waste and uncertainties of the "human element" in lubrication.

Design more efficient, more economical, foolproof automatic lubrication into your machines. Mail coupon below for full details!

8 Advantages of the ALEMITE OIL-MIST System

1. Continuous Lubrication—Constantly deposits fresh, clean film of oil on all surfaces of all bearings in the system.

2. Fully Automatic Lubrication—Can start and stop with operation of machine switch.

3. Elimination of Guesswork—No bearing can be overlooked, nor overlubricated! Every bearing picks up only as much Oil-Mist as it needs. Eliminates waste.

4. Reduction of Bearing Temperatures—Acts as bearing coolant, can lower bearing temperatures as much as 20° F.

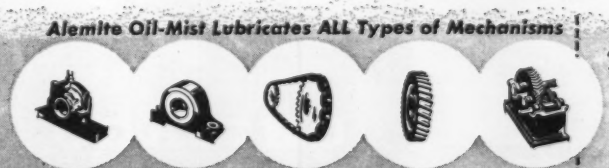
5. Reduction of Types of Oil—Reduces number of oils that must be stocked, handled, and applied.

6. Elimination of Downtime—All bearings in the system are constantly lubricated while machines continue to operate. Production goes up!

7. Extension of Bearing Life—Multiplies bearing life many times. Life of grinding machine bearings has extended from 400 to 7,000 hours!

8. Less Oil Consumption—about 1/10 the amount consumed by any other lubrication method!

Alemite Oil-Mist Lubricates ALL Types of Mechanisms



Anti-friction Bearings | Plain Bearings | Chain | Gear | Gear Cases

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OIL-MIST

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A Product of STEWART-WARNER CORPORATION

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☐ Please send me a FREE copy of your new and complete Alemite Oil-Mist catalog.

☐ Please have your Alemite Lubrication Representative arrange a no-obligation demonstration.

My Name _____

Title _____

Company _____

Street _____

City _____ State _____

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LOCKS E. P. LUBE IN FOR A FAST PINION

In the dashing, new Rambler, the rear pinion may turn up to 3800 rpm—and, on a hot day, lube temperature may run 250° or more . . . and it is vital that the E.P. lubricant protecting this pinion be retained under all operating conditions. American Motors posed this key problem to Chicago Rawhide: provide a pinion seal that would more than withstand the temperature involved, and equally important, resist the deteriorating effects of a high sulphur content in E.P. lubricants. C/R engineers recommended the new C/R Type W Oil Seal. Result: this unique seal is delivering positive, dependable sealing performance under the most rugged road conditions.

Do you have a difficult sealing problem? C/R engineers will welcome the opportunity to work with you in the selection of the correct seal style and material for your application. Write for detailed information.

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

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Export Sales: Geon International Corp., Great Neck, New York

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CHICAGO RAWHIDE

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THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

September 6, 1956
Volume 28—No. 18

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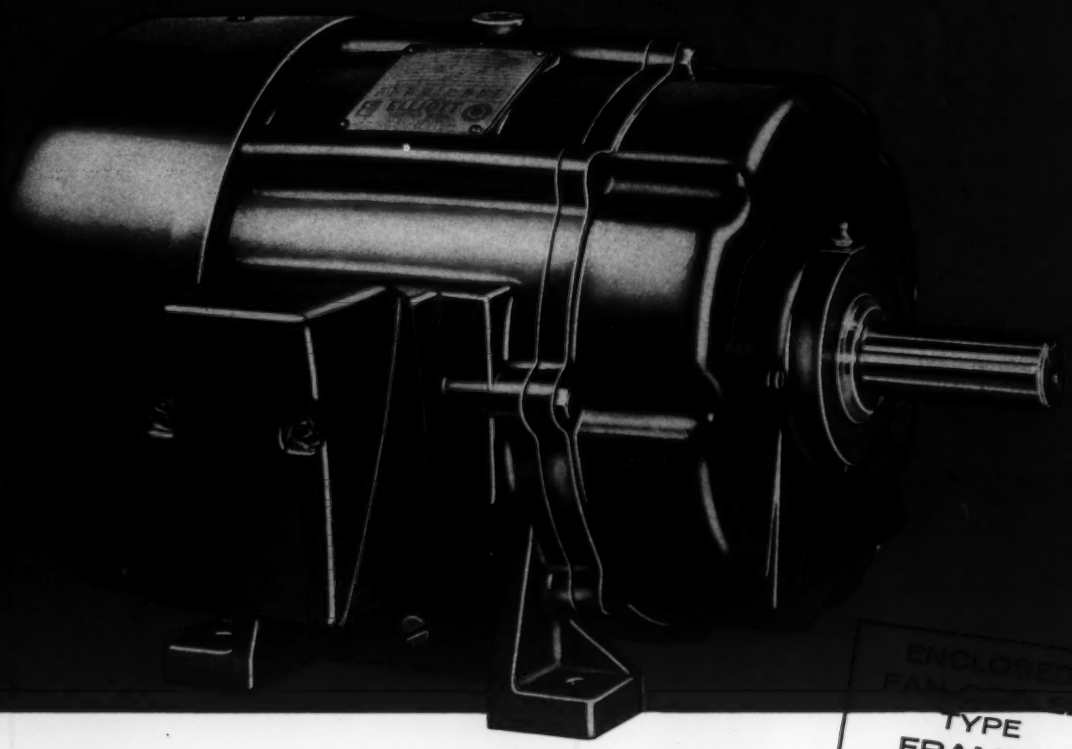


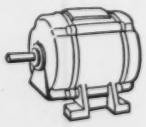
Elliott C-W Type N Motors

NEW PERFORMANCE! You get more horsepower per pound from these compact Elliott C-W motors because of their improved design, and the use of vastly superior insulating materials and electrical steels. Due to greater mechanical and dielectric strength, insulating materials occupy less space. More space is available for copper—the "muscle" of the motor.

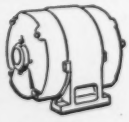
NEW PROTECTION! Internal parts of Elliott C-W motors are completely protected by rugged housings — dripproof, or totally-enclosed, as required. Efficient fans assure ample cooling.

NEW DEPENDABILITY! New Elliott C-W type N motors are designed for the utmost in dependability. They will withstand physical abuse. Use of highly dependable insulating materials assures prolonged life; anti-friction bearings are available in several optional types, to meet severe service conditions.

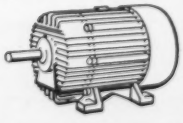
OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated



Dripproof Protected



Totally-enclosed, fan-cooled (ribbed frame)

ELLIOTT Company

CROCKER-WHEELER DIVISION

WRITE for new bulletin describing Elliott C-W Type N Motors. Address: Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.

W8-4

Engineering News Roundup

System Reads and Transcribes Electrical Quantities

Provides Data for Time-Interval Plotting

PITTSBURGH, PA.—A new system of surveying continuously fluctuating electrical quantities has been developed by Westinghouse Electric Corp. Virtually automatic, the system employs basic modern techniques of data gathering and processing. Original data is accumulated on magnetic tape and values at regular time intervals are transcribed onto punched cards. The present application of the system is to determine the nature of power loads in electric utility systems.

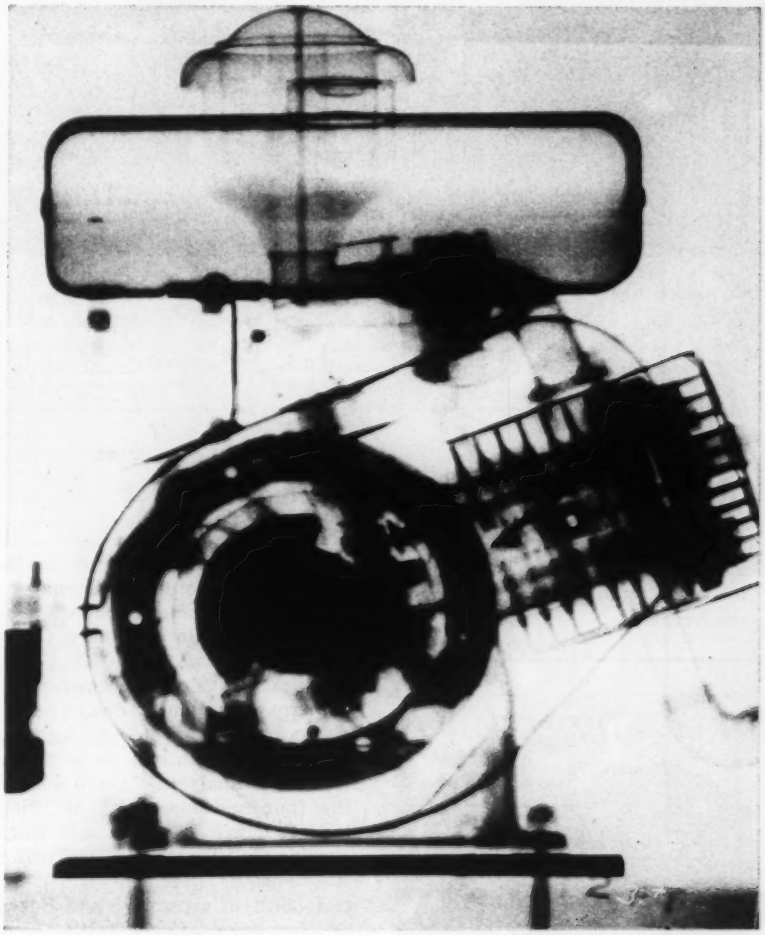
Components of the system include: (1) a compact recorder which connects to a watt-hr meter and enters impulses on magnetic tape to represent time and demand values, (2) a translator that interprets the impulses, and (3) a summary card punching machine which transcribes demand values to standard cards prepunched with constant survey information.

All functions except data gathering are concentrated in the translator and the card punch machine which function as central office equipment. The recorder operates at the point of origin of the load without interference with normal metering.

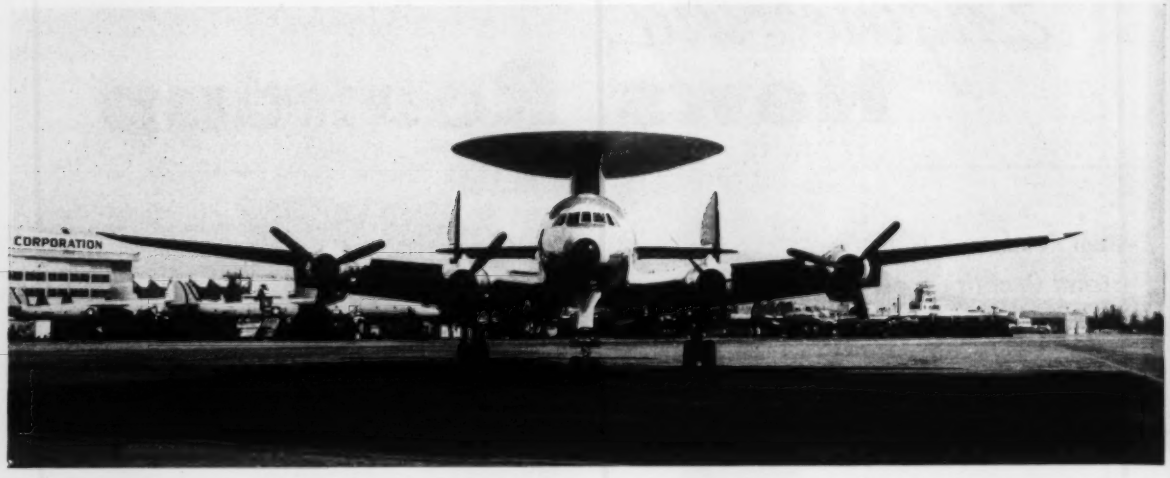
The recorder uses standard 600-ft lengths of dual-track magnetic tape and operates at a tape speed of 9.4 in. per hr. Standard tape lengths permit a 32-day survey run.

After a survey has been run, the tape is brought to a central location for play-back. The translator unit totals and converts time and load impulses into demand values. Tapes are processed at 3¾ ips, when 15-min demand intervals are desired, or at 7½ ips for 30 or 60-min demand intervals.

Each of the punched cards accommodates 16 demand intervals; one card is adequate for a 4 hr survey period when the demand interval is 15 min. At this interval, 2880 readings taken during a one-month survey run can be contained



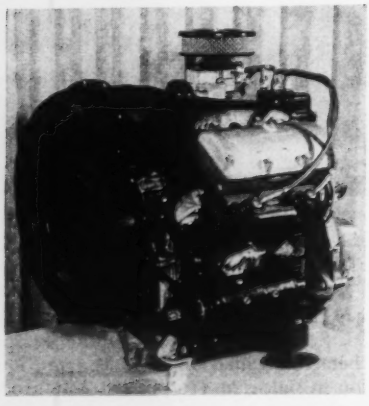
X-RAY MOVIES OF A RUNNING ENGINE have been made at Detroit Arsenal with a new stroboradiographic technique developed co-operatively by the Arsenal and General Electric Co. Special stroboradiographic equipment employs a high-energy industrial betatron which operates at 5 million to 15 million volts and furnishes radiation in pulses at 416 per sec. The process involves taking thousands of exposures accurately synchronized with the moving parts of a subject. Exposure time is 10 to 15 millionths sec. The exposures super-imposed form a strong image of the subject at one point in its cycle. To obtain slow-motion movies of a piston, for example, X-ray stills are taken at various points in the piston cycle and spliced together in sequence.



FLYING SAUCER RIDES PIGGYBACK on a Navy WV-2 Super Constellation, carrying an experimental flying radar installation. The elliptic radome, measuring over 30 ft across, contains distance-determining radar antenna. The installation was designed and built by Lockheed as an application of advanced ideas in airborne radar detection, to be employed as a protection against surprise attack.

in 180 cards.

Numerous surveys of this type will provide timely and accurate data by which system loads can be anticipated. Current forecasts indicate that average residential loads are to double within the next ten years.



NUMEROUS ALUMINUM PARTS keep the weight of this 62-hp, V-4 engine down to only 200 lb. Cylinders, cylinder heads and covers, and timing gear housings are aluminum diecastings. These and other aluminum parts make up 70 lb of the weight of the 2 by 2 by 2-ft engine. The Aluminum Co. of America and American Motors Corp. collaborated on the development of the engine.

Electronics Symposium Program Announced

CLEVELAND, O.—Subjects and speakers have been announced in the program of the Fifth Annual Industrial Electronics Symposium to be held at the Hotel Manger, Cleveland, September 24 and 25. Four sessions will be concerned with: Electronic equipment design; automatic production; testing, gaging and process control; data reduction and analysis. Chairmen of the four sessions are J. W. Picking, Reliance Electric and Engineering Co.; Roger W. Bolz, editor, *Automation;* Herman R. Weed, Ohio State University; and Forest D. Brammer, Case Institute of Technology.

Luncheon on the first day of the symposium will feature a talk by Benjamin W. Chidlaw, vice president, Thompson Products. Luncheon on the second day will feature an award presentation by the Professional Group on Industrial Electronics of the Institute of Radio Engineers.

Selected subjects of talks and speakers from the complete program are:

Short Cuts in Printed-Circuit Wiring, by Robert Ost, Sperry Gyroscope Co., Great Neck, N. Y.

Human Engineering—An Aid to Improving Electronic Equipment, by Maurice Rappaport, Stanford Research Institute, Menlo Park, Calif.

Status of Standardization in Electronics Production and Machine Tool Control, by Elmer H. Bosman, International Business Machines, Endicott, N. Y.

Production Testing in the Automatic Factory, by Herbert S. Dordick, Radio Corp. of America, Camden, N. J.

The Industrial Electronics Concept, by Eugene Mittelmann, Consulting Engineer, Chicago, Ill.

Variable-Speed Electronic Drives for Process Control, by A. J. Humphrey, Reliance Electric and Engineering Co., Cleveland, O.

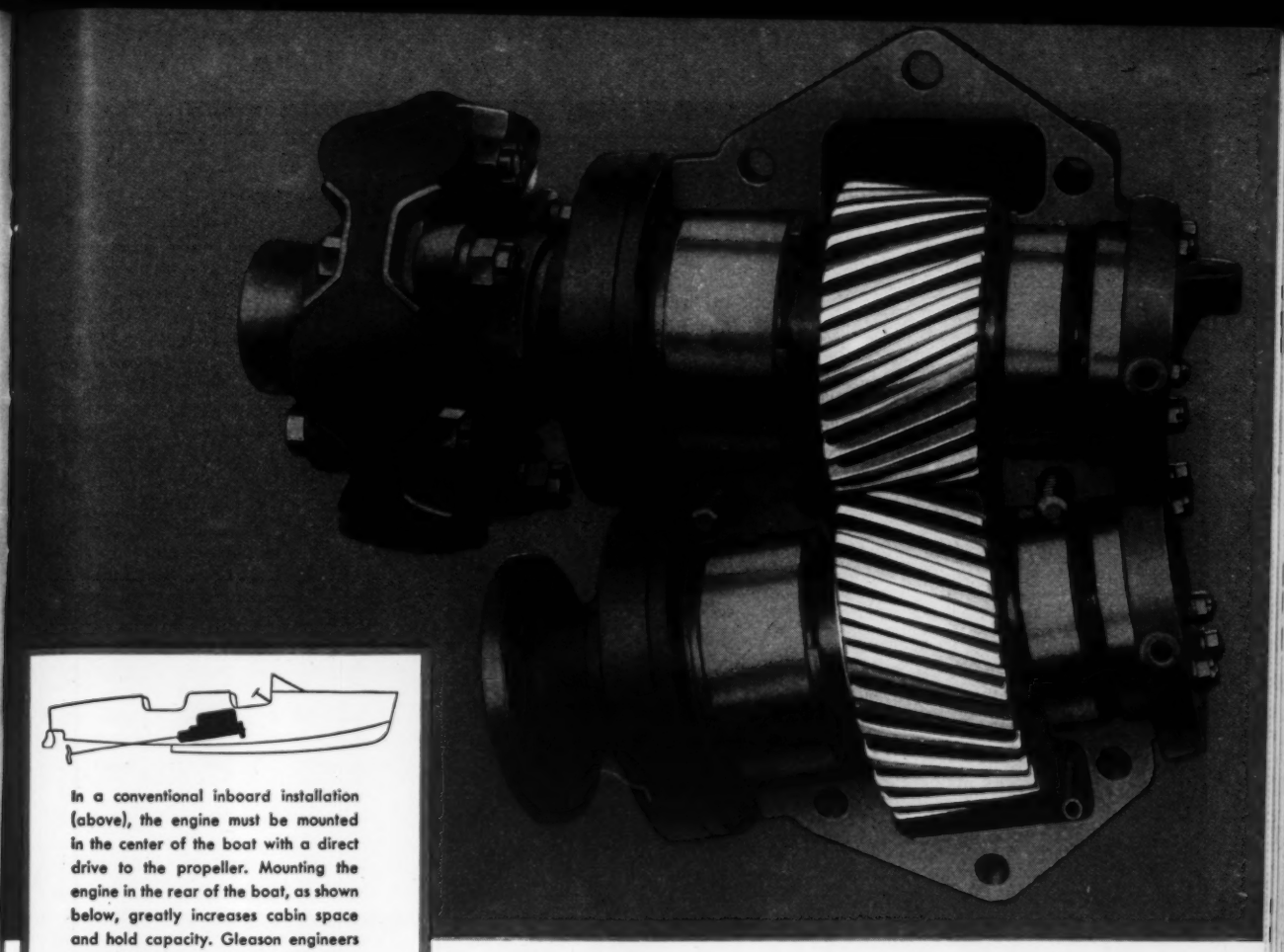
Analysis of Motor Speed Control System with an Analog Computer, by William J. Bradburn, Louis Allis Co., Milwaukee, Wis.

Computers—The Key to Modern Manufacturing Scheduling, by Jean-Paul J. Gravel and Thomas F. Kavanagh, General Electric Co., Schenectady, N. Y.

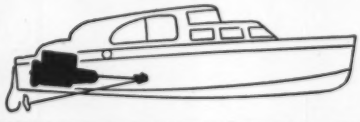
The members of the planning committee are: Reuben Kazarian, Ohio Crankshaft Co., cochairman; Byron Jones, Curtiss-Wright Corp., cochairman; Robert C. Rodgers, MACHINE DESIGN, program chairman; Carl Schuneman, Thompson Products Inc., publicity chairman; Tony Furfari, Westinghouse Electric Corp., local arrangements

Front Cover

Panel, door and closure seals are quite different from conventional higher pressure hydraulic or pneumatic seals. Designed to keep out rain, weather and to maintain low pressure differentials, panel and door seals can be quite complex in cross section. These unusual cross section shapes have been neatly pictured by artist George Farnsworth to highlight R. W. Beckim's article (see Contents page).



In a conventional inboard installation (above), the engine must be mounted in the center of the boat with a direct drive to the propeller. Mounting the engine in the rear of the boat, as shown below, greatly increases cabin space and hold capacity. Gleason engineers assisted the Marine Engine Manufacturers in the development of the V-Drive.



Angular power transmission can improve *your* product, too

Take, for example, this marine V-Drive. The use of spiral bevel gears permitted a design which released more usable space in the boat, improved balance, and simplified installation.

This is just one instance of the added flexibility of product design possible with angular power transmission.

Faster production and lower costs will also result from using this type of transmission.

If you have a design application for bevel or hypoid gears, the Gear Engineering Department of the Gleason Works is ready to help you realize every advantage possible. Design and production recommendations for your angular drive are offered at no obligation.

If you would like to discuss your bevel gear application with a Gleason representative, please contact us.

These Gleason Technical Handbooks are available on request:

Spiral Bevel Gear System
20 Straight Bevel Gear System
Zerol® Bevel Gear System

GLEASON WORKS

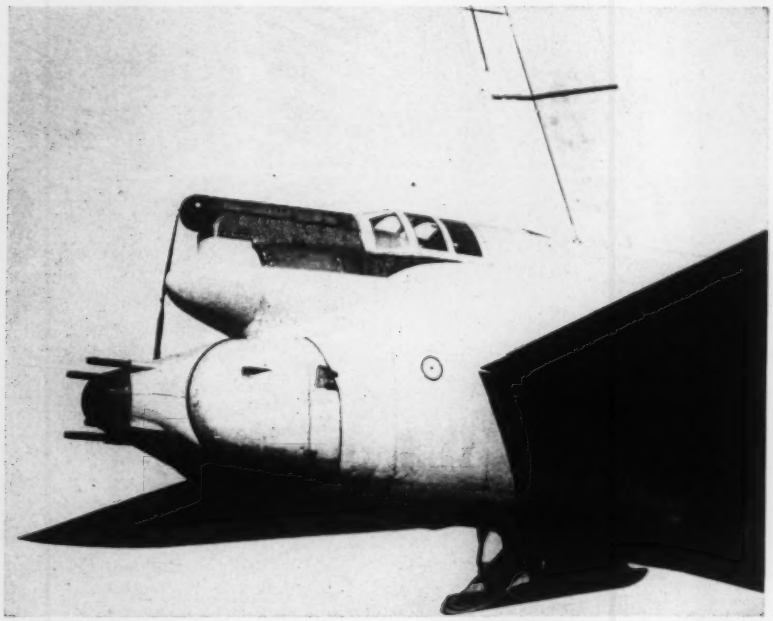
Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Circle 507 on page 19

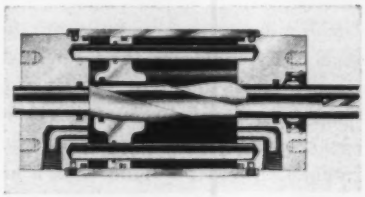
chairman; and Henry Martin, Ambos-Jones Co., financial chairman.

Information on registration can be obtained from the registration chairman, L. A. Koenig, Clark Controller Co., 1146 East 152nd St., Cleveland 10, Ohio.



B-52 DEFENSIVE SYSTEM, made by Arma Div. of American Bosch Arma Corp., enables one gunner to do the work of six men on older model bombers. Automatically, the system continuously determines range, range rate, angular position, own speed, enemy speed, air temperature, altitude, roll and pitch of own ship, and trajectory characteristics. The system aims the guns and signals the gunners when to fire, but for safety to friendly planes the firing is not automatic. The system cannot distinguish between friend and foe. Eight separate systems, including radar, optical and gun-feed, comprise the defensive assembly, but the complete system is lighter than were the manual systems on the smaller B-17 or B-24 bombers.

Positive-Stop Actuator Operated by Fluid or Gas



LANSING, ILL.—A new rotary power mechanism designed to operate on air, gas, water or oil pressure has been announced by Carter Controls Inc. Called the Carter Rotary Actuator, the unit delivers rotary motion by means of a piston and internal helix.

Possible applications include: indexing, positioning, valve actuating, gate opening, breech locking, rolling, clamping and lifting.

According to the manufacturer, the actuator can be stopped at any point in the rotation cycle and held there indefinitely even if a complete power failure occurs. Position of the work load is not affected by reverse tension, shock or vibration.

The actuator is completely enclosed and operates on pressures from 5 to 500 psi. Standard rotation cycles are: 0 to 100 degrees, 0 to 90 degrees, 0 to 280 degrees, and 0 to 370 degrees.

Topics

Designed any space ships lately? If so, the Air Force would like to know about them. The Innovations Division of the Air Research and Development Command is eager to receive and evaluate any serious ideas on aerial vehicle design, the theory being that among such ideas could be some that would lead to important developments.

• • •

First U. S. laboratory for instruction in shaped diamond tool technology has been established at Illinois Institute of Technology. A course in the construction and use of such tools will be offered there this fall.

• • •

Biggest aluminum pipe ever extruded in the United States is the distinction claimed for some 16-in. OD pipe produced by Alcoa. It has ¾-in. thick walls and is made in 31-ft lengths.

• • •

New speed record of 1900 mph has been set by an Air Force pilot in the Bell X-2 rocket plane. The swept-wing experimental plane was carried aloft by a B-50 for its speed run. Maximum speed that the X-2 is expected to attain is in the range of 2200 to 2500 mph.

• • •

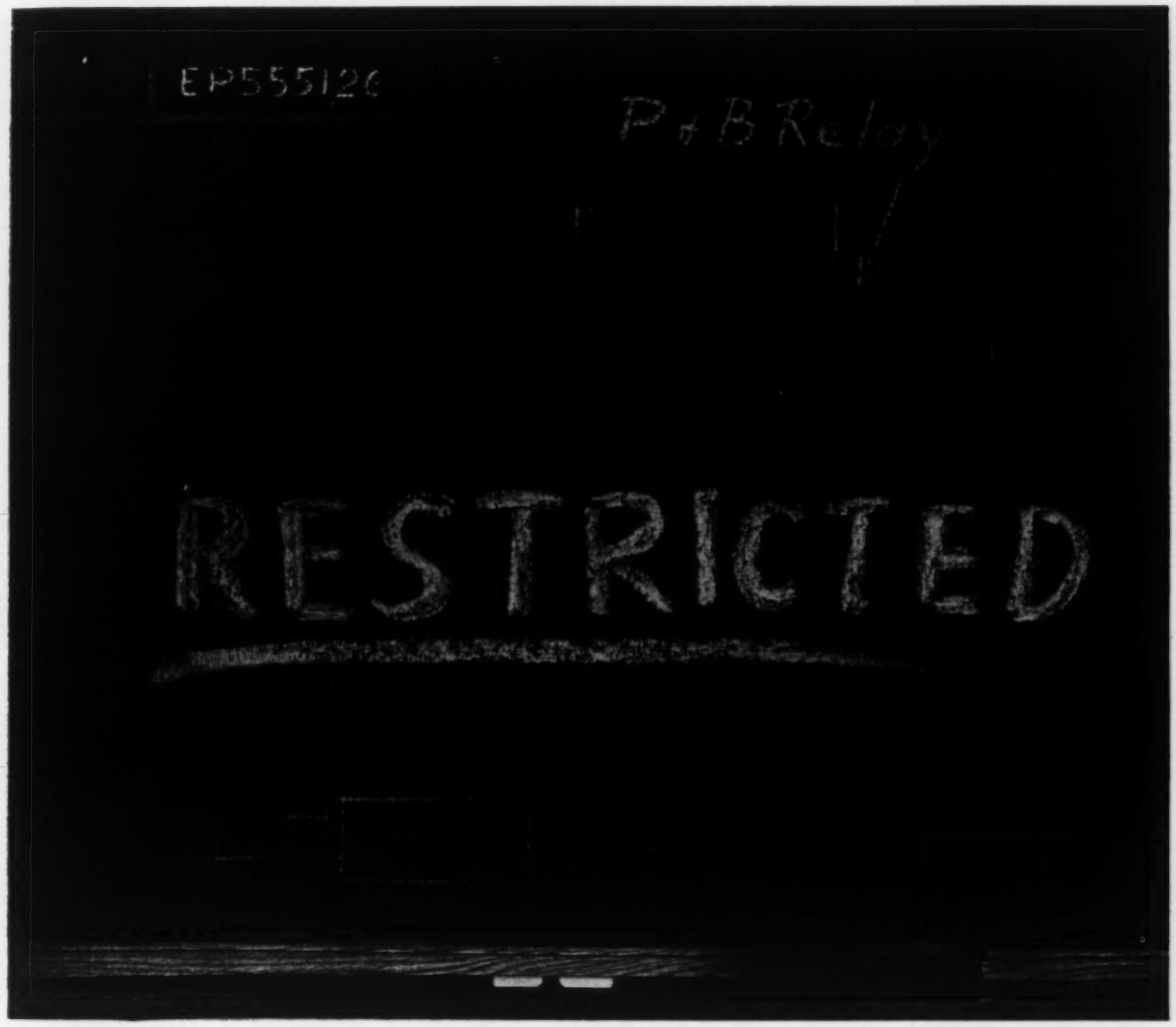
Dept. of what's in a name reveals that the first two of a new line of Navy ammunition-carrying ships are called *Suribachi* and *Mauna Kea,* making both of them namesakes of volcanoes.

• • •

Music, music, music — at the rate of 1000 melodies an hour—can be produced by the Datatron electronic brain. A formula that substitutes numbers for notes and equations for tempo is fed to the computer. The formula expresses long-established melody-writing rules. Tunes are printed on an electric typewriter in the form of capital letters and rhythm symbols.

• • •

First commercial magnesium plant built in this country since World War II will have a capacity of 10,000 tons a year. The plant will be located at Selma, Ala., and is scheduled for completion late next year.



P & B answers newest jet bomber relay need

puts big performance in tiny package

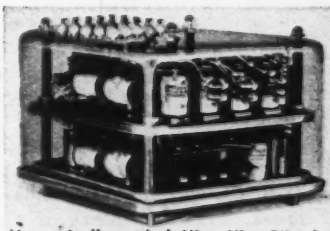
Modern supersonic aircraft call for an entirely new concept of relay performance *and* miniaturization. Vital relays must have incredible sensitivity . . . multiplicity of action . . . unquestioned reliability. And they must be smaller than ever before!

Yet P&B has engineered and produced a relay for the world's most spectacular jet bomber, now in experimental production, that meets *all* these demands.

Though details of application are restricted, we can tell you *this*. The new P&B unit is really 19 individual relays in one 6" x 6" x 5" package that actually *outperforms a previous unit nine times the size!*

Your relay requirements may not be those of a jet bomber. But *whatever* your problem or application, "standard" or special, you can be sure you too will find the answer with the *relay leader* . . . P&B.

Write for your new Engineering Guide today.



Hermetically sealed 6" x 6" x 5" relay unit adds to P&B's more than 20,000 relay design variations.

Potter & Brumfield inc.
PRINCETON, INDIANA
Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY

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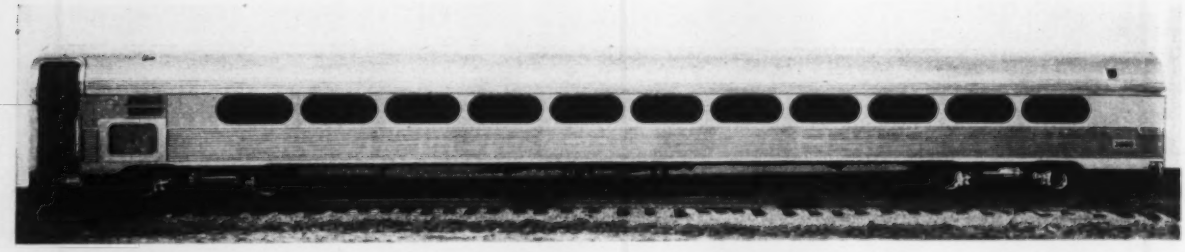


"Pioneer III" introduced by the Budd Co. is claimed the lightest railway coach to meet standard strength requirements. It is 85 ft long, carries 88 passengers, weighs 595 lb per passenger.

Lightweight Rail Coach Meets Size, Safety Standards

PHILADELPHIA, PA. — The lightest railway car to meet standard strength requrements has been announced recently by the Budd Co. Called "Pioneer III," the new car combines stainless-steel construction with extensive use of plastics.

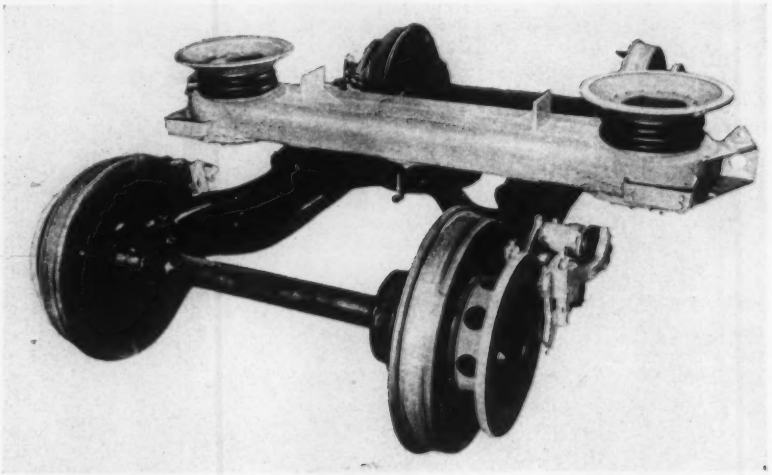
A high-capacity mainline coach version has the standard length of 85 ft, seats 88 passengers and weighs 61,000 lb. Other adaptations of the basic car are: 125-passenger commuter coach, 52-passenger mainline coach, 60-passenger diner, tavern-lounge car and sleeper.

Pioneer III has four-wheel trucks and coupler heights which permit it to be hauled by any standard tractive unit. Any mechanical part of the car can be replaced in one hour.

The principal structure of the car is welded stainless steel. Two members which form a divided center sill connect to collision posts at the ends of the car. Electric train lines run through the sill. Extensive insulation also functions as sound-deadening material.

Each truck on the Pioneer III weighs 6320 lb as compared with 18,000 lb of the current standard car truck. Principal parts of the light truck are side frames, a truck bolster, and two air springs.

The air springs work in conjunction with a large reservoir which serves to soften the rate of the springs. Each spring and the reservoir are connected by an orifice to restrict the passage of air between the two. This results in a spring with a variable spring rate and built-in damping which varies according to the frequency and displacements of the spring.



Simplified, lightweight trucks on the Pioneer III coach feature air-spring suspension system. Commuter-coach trucks have four motors each.

Truck side frames, formed of two stampings welded together, are allowed to articulate around a central pivot bearing. These side frames carry roller journals mounted inboard of the wheels. The use of inside journal bearings allowed a lighter axle, accessible installation of a disk brake outside the wheel, and easier wheel maintenance.

First Automation Conference Scheduled at Purdue

CLEVELAND, O.—The complete program has recently been announced for the First Conference on Manufacturing Automation to be held at Purdue University, Lafayette, Ind., October 22-24. Sponsors are the Schools of Mechanical Engineering and Industrial Engineering at Purdue and the technical journal, *Automation*, Cleveland.

The Conference program is designed to help promote better understanding of manufacturing automation technology and its practical application. The basic aim is to provide a broad insight into this complex area and a common meeting place for key engineering and manufacturing executives vitally interested in attaining realistic results.

Highlights of the program are the following talks:

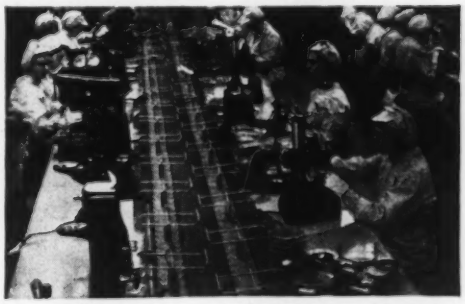
The Product by W. M. Schweder: What effects on practical automation result from basic product design? Can the product be tailored for more economical automation? For making automation practical?

Using Standard Equipment by D. A. Cargill: What are the attributes and economics of using standard equipment with available and/or specially designed attachments and devices?

"Building Block" Equipment by P. H. Richardson: There is the possibility of using "building block equipment" to build up semi-special machines. This approach has considerable merit and its attributes and economics

NEW DEPARTURES OF TODAY

Microscopic inspection of races, one of more than one hundred operations undertaken to insure the highest degree of uniformity and dependability.



Super-cleanliness is a byword in this ball bearing assembly and inspection area. It is completely air-conditioned and pressurized to keep out dust.

Volume source for *miniature* ball bearings!

These tiny steel "jewels" are available in a complete line, 3/8" (.375") outside diameter and smaller. They are made with super-accuracy on the finest equipment available—much of it designed by New Departure—to meet the most exacting requirements of today's precision industries. Performance and dependability of the highest order are assured.

For complete information about miniature ball bearings, or for help with any bearing problem, call on New Departure's experienced engineering service. New Departure, Division of General Motors Corporation, Bristol, Connecticut.

WRITE FOR NEW DEPARTURE'S MINIATURE BEARING CATALOG

GM GENERAL MOTORS

NEW DEPARTURE

BALL BEARINGS

NOTHING ROLLS LIKE A BALL

should be carefully evaluated.

Transfer Machines by R. E. Cross: Transfer machines have reached a high state of development and today offer outstanding possibilities.

Special Purpose Lines by Robert Sattler: It is possible to develop completely special-purpose production equipment from the ground up. This is often the only answer for very high production with products of new or unusual character or where complete processing from raw materials to finished product is necessary.

Do It Yourself? by C. F. Carlzen: Should you create an engineering group to automate operations? What are the advantages?

Use the Specialist? by R. B. Billingham: The question is "should you use the machine and equipment specialists?" What are the advantages?

Use the Consultant? by I. Ingraham & J. Y. Rust: If a large-scale project involves diverse areas of manufacturing talent, some of which are unfamiliar to present personnel, should you use the automation consultant?

Planning committee for the Conference is: E. S. Ault, professor, School of Mechanical Engineering, Purdue, cochairman; R. W. Bolz, editor, *Automation,* cochairman; H. T. Amrine, professor, School of Industrial Engineering, Purdue; J. C. Keebler, associate editor, *Automation;* O. D. Lascoe, professor, School of Industrial Engineering, Purdue; Dr. G. E. Davis, director, Division of Adult Education, Purdue; K. E. Glancy, conference supervisor, Division of Adult Education, Purdue.

Additional information on the conference, lodging, and transportation details may be obtained by mail or phone from K. E. Glancy, Div. of Adult Education, Purdue University, Lafayette, Ind.

Solid Lubricant for Nylon Liquefies Under Pressure

DETROIT, MICH.—Development of a new lubricant for nylon, intended specifically to provide a dry seal against oxidization and contamination of bearing surfaces, has been announced by Synco Co.

Properties of the new lubricant result from its content of multiple additives and corrosion inhibitors in a "solid" base. Called Nylube, the new dry base lubricant employs the principle of regelation, becoming wet and slippery as pressure is applied, then resolidifying as pressure is relieved.

Very small quantities of Nylube are required for most efficient operation. Parts are dipped or sprayed with a very light film. Average period between reapplications is 6 months.

Fine Holes in Glass Help Extend Computer Memories

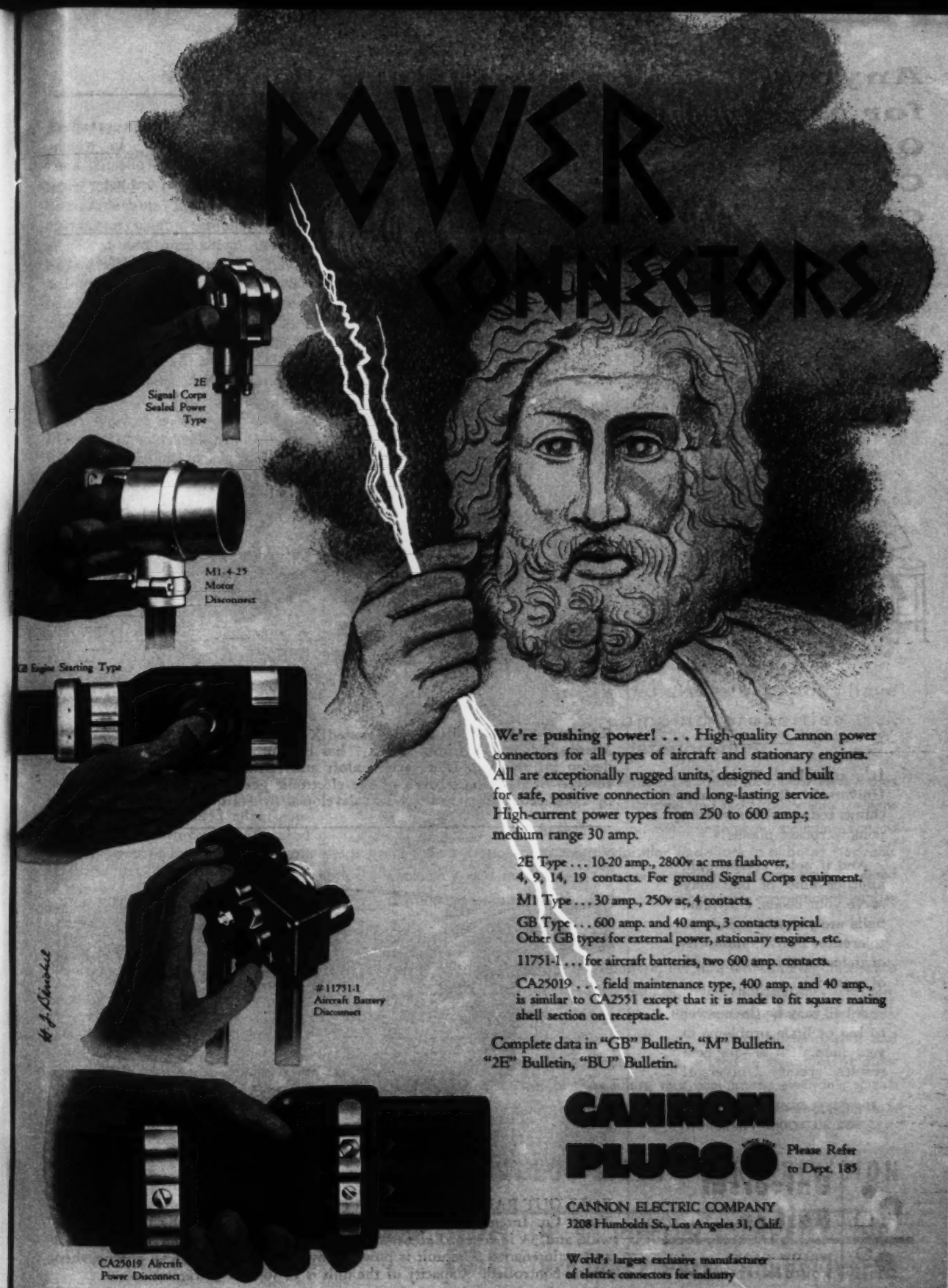
SCHENECTADY, N. Y.—Smaller computers with bigger memories may soon be made possible by a new G-E information storage tube. A feature of the tube, described recently by Dr. Harold R. Day of the G-E Research Laboratory, is a thin sheet of glass in which extremely small holes have been etched in a honeycomb pattern and filled with metal.

The holes in the honeycomb are spaced 500 to the inch. Each square inch has 250,000 individual storage cells, and each cell will recognize at least 10 different levels of intensity from the tube's writing gun. Logarithmic calculations increase to more than 800,000 the number of bits of information that can be stored at one time.

Information is written onto one side of the honeycomb by an electron-beam scanning method similar to that used in television. A "reading gun" picks up the information from the opposite side. Early laboratory models have permitted storage for several minutes and Dr. Day is confident the time can be extended.

Two methods of reading the information are available. In one method the electron beam erases the screen as it picks off the stored information. In the other method,

Glass plate held by G-E's Dr. Harold R. Day is the heart of this new information storage tube. The plate has 250,000 holes per square inch filled with metal according to the pattern seen on the TV screen.


POWER CONNECTORS
2E Signal Corps Sealed Power Type
M1-4-25 Motor Disconnect
GB Engine Starting Type
#11751-1 Aircraft Battery Disconnect
CA25019 Aircraft Power Disconnect
We're pushing power! . . . High-quality Cannon power connectors for all types of aircraft and stationary engines. All are exceptionally rugged units, designed and built for safe, positive connection and long-lasting service. High-current power types from 250 to 600 amp.; medium range 30 amp.
2E Type . . . 10-20 amp., 2800v ac rms flashover, 4, 9, 14, 19 contacts. For ground Signal Corps equipment.
M1 Type . . . 30 amp., 250v ac, 4 contacts.
GB Type . . . 600 amp. and 40 amp., 3 contacts typical. Other GB types for external power, stationary engines, etc.
11751-1 . . . for aircraft batteries, two 600 amp. contacts.
CA25019 . . . field maintenance type, 400 amp. and 40 amp., is similar to CA2551 except that it is made to fit square mating shell section on receptacle.
Complete data in "GB" Bulletin, "M" Bulletin. "2E" Bulletin, "BU" Bulletin.
CANNON PLUGS
Please Refer to Dept. 185
CANNON ELECTRIC COMPANY
3208 Humboldt St., Los Angeles 31, Calif.
World's largest exclusive manufacturer of electric connectors for industry
Circle 510 on page 19

Anyone for a Quality Controlled Crystal Ball?

It's possible! There's a Universal ball for so many things today—from writing pens to rocket planes!

And if not a *crystal* ball, another kind of ball may serve your needs. Universal balls are precision-made to tolerances of five millionths of an inch and in many types of material.

A ball may be the answer to big or little problems in *your* field. If it is—for best results, specify Universal!

UNIVERSAL QUALITY CONTROL—
FOR ALL ROUND PERFECTION!

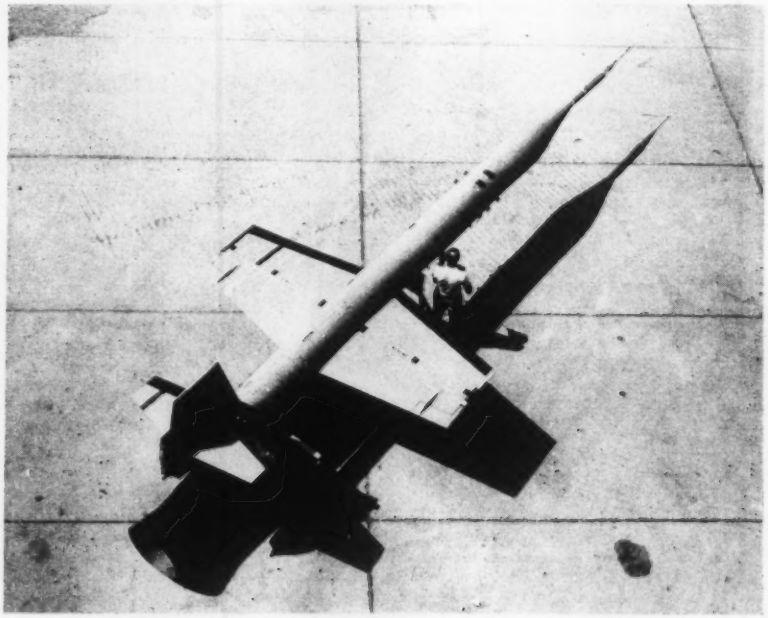
Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

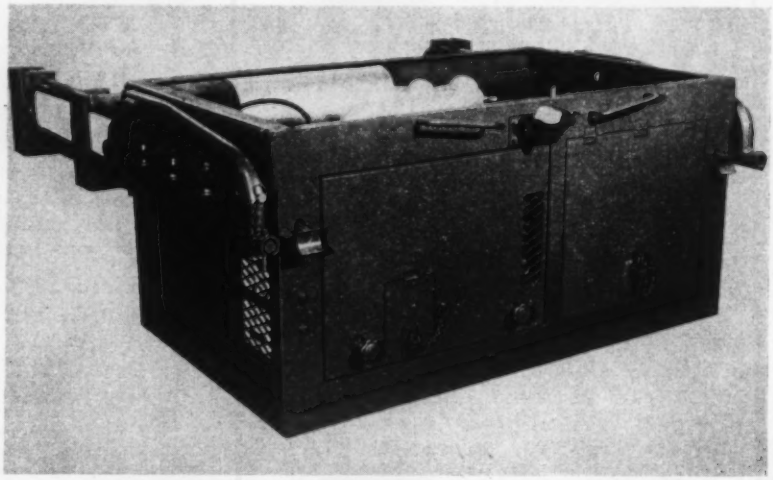
Circle 511 on page 19

the information can be left for re-reading, to be altered or added to by the writing beam.

Possible applications for the new storage tube, in addition to computers, include television cameras and "scan converters" in which radar information is collected and then displayed on an ordinary television screen.



RAMJET TEST VEHICLE, designated X-7, is a recent product of Lockheed Missile Systems Division. The X-7 has been flown to accumulate test and design information. It is carried aloft and released from a B-29, then recovered by parachute. Much of the electronic gear it carries was developed by Lockheed, and the ramjet was developed by Marquardt.



ROLL-OUT RAILWAY CAR AIR CONDITIONER has been introduced by Trane Co. Intended for installation below railway cars, the unit is 55 in. wide and 33 in. deep. Extension tracks allow unit to roll out for inspection and maintenance. The unit is powered by a four-cylinder diesel engine, thermostat-controlled. Capacity of the unit is 15 tons of refrigeration.

High-Temperature Silver Alloy Retains Conductivity, Hardness

NEW YORK, N. Y.—A new oxidation-hardenable high-silver alloy, offering a useful combination of electrical and mechanical properties, has been developed by Handy & Harman, manufacturer of silver alloys. The new alloy is a silver-magnesium-nickel composition, normally consisting of about 99.53 Ag, 0.27 Mg, and 0.20 Ni.

The principal characteristic of the new silver alloy is that it is easily worked while soft and then irreversibly hardened by heating in air. Once hardened, the alloy is highly resistant to softening, has a low creep rate, and for all practical purposes does not anneal at elevated temperature. If annealing is necessary after initial working, it can be done in 15-30 minutes in air at 700 F or in non-oxidizing atmosphere above 700 F. Permanent oxidation hardening is produced at 1200-1475 F, the time and temperature cycle depending on the thickness of the piece.

In oxidation-hardened condition, tensile properties at room temperature are similar to those of hard rolled coin or sterling silver. At elevated temperatures, hot hardness and strength are considerably better than hard-rolled silver-copper alloys. However, at elevated temperatures, high hardness and strength are accompanied by reduced ductility, and the material tends to fracture rather than creep at excessive stresses.

Hardened parts of Ag-Mg-Ni alloy can be brazed in air without danger of annealing, using silver brazing alloys and an active paste flux. The alloy can also be soft soldered. Corrosion resistance is similar to that of fine silver, and resistance to salt corrosion is excellent.

Electrical conductivity is appreciably better than that of phosphor bronze A, beryllium copper 25, and beryllium copper 10 at all temperatures. Conductivity ranges between 78-50 percent IACS over a temperature range of 50 to 500 F. Modulus of elasticity is 12×10^6 at room temperature.

(*Continued on Page* 22)

ALLOY WIRE Cushions...

take the SHAKES out of AIRCRAFT INSTRUMENTS

Fabricated all-metal mounts have high damping properties . . . Resist deterioration.

Robinson Aviation, Inc., Teterboro, New Jersey, uses knitted stainless steel and nickel alloy wire cushions in their new all-metal engineered mounting systems to control vibration and shock in airborne electronic equipment and instruments. Alloy wire resilient cushions have attained performance standards heretofore impossible with conventional rubber or synthetic materials.

When fabricated into a special pattern, the wire forms literally thousands of tiny interlocking springs. Their high damping characteristics and non-linear spring rate provide ample protection against dynamic overloads. Alloy wire resists deterioration by oil, water, ozone, bacteria, dust and extreme temperatures. Knitted alloy wire is used in hundreds of other industrial applications, such as filters, mist eliminators, electronic shielding. For further information send today for our Application Bulletin A-1.

ALLOY METAL WIRE DIVISION

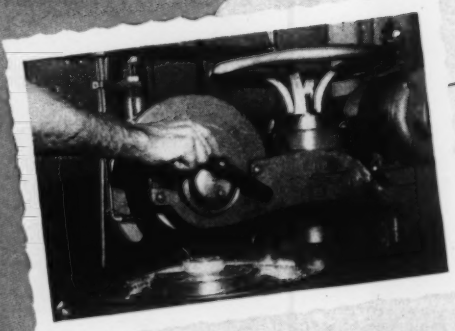
HKP H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

Circle 512 on page 19

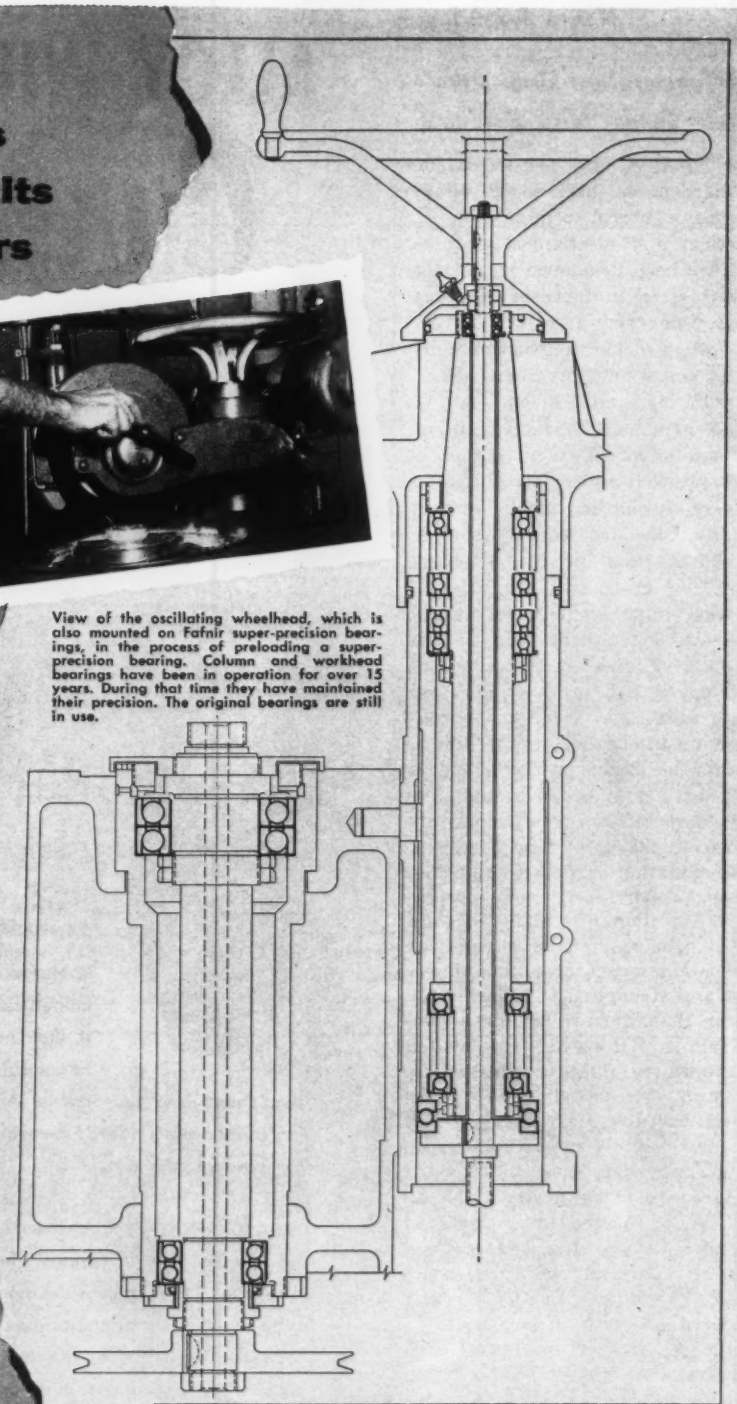
How a precision surface grinder is designed to hold its precision for years

The job of preloading super-precision ball bearings calls for grinding precise amounts of stock from the faces of bearing rings. To obtain such results with a satisfactory degree of efficiency requires a grinder designed to maintain maximum rigidity and precise swiveling of its wheelhead arm plus precise rotation of its work spindle.

The diagram at the right shows how such rigidity is built into a precision surface grinder. All bearings indicated except the thrust bearing at the bottom of the column which supports the wheelhead arm are Fafnir super-precision, preloaded types. The use of these Fafnir ball bearings has resulted not only in work of dependable accuracy and finish, but also longer machine life. For other application data on Fafnir super-precision bearings plus dimensional and load rating details, write for Fafnir Precision Ball Bearing Catalog. The Fafnir Bearing Co., New Britain, Conn.



View of the oscillating wheelhead, which is also mounted on Fafnir super-precision bearings, in the process of preloading a super-precision bearing. Column and workhead bearings have been in operation for over 15 years. During that time they have maintained their precision. The original bearings are still in use.



FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
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413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
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417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
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420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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MACHINE DESIGN
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401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
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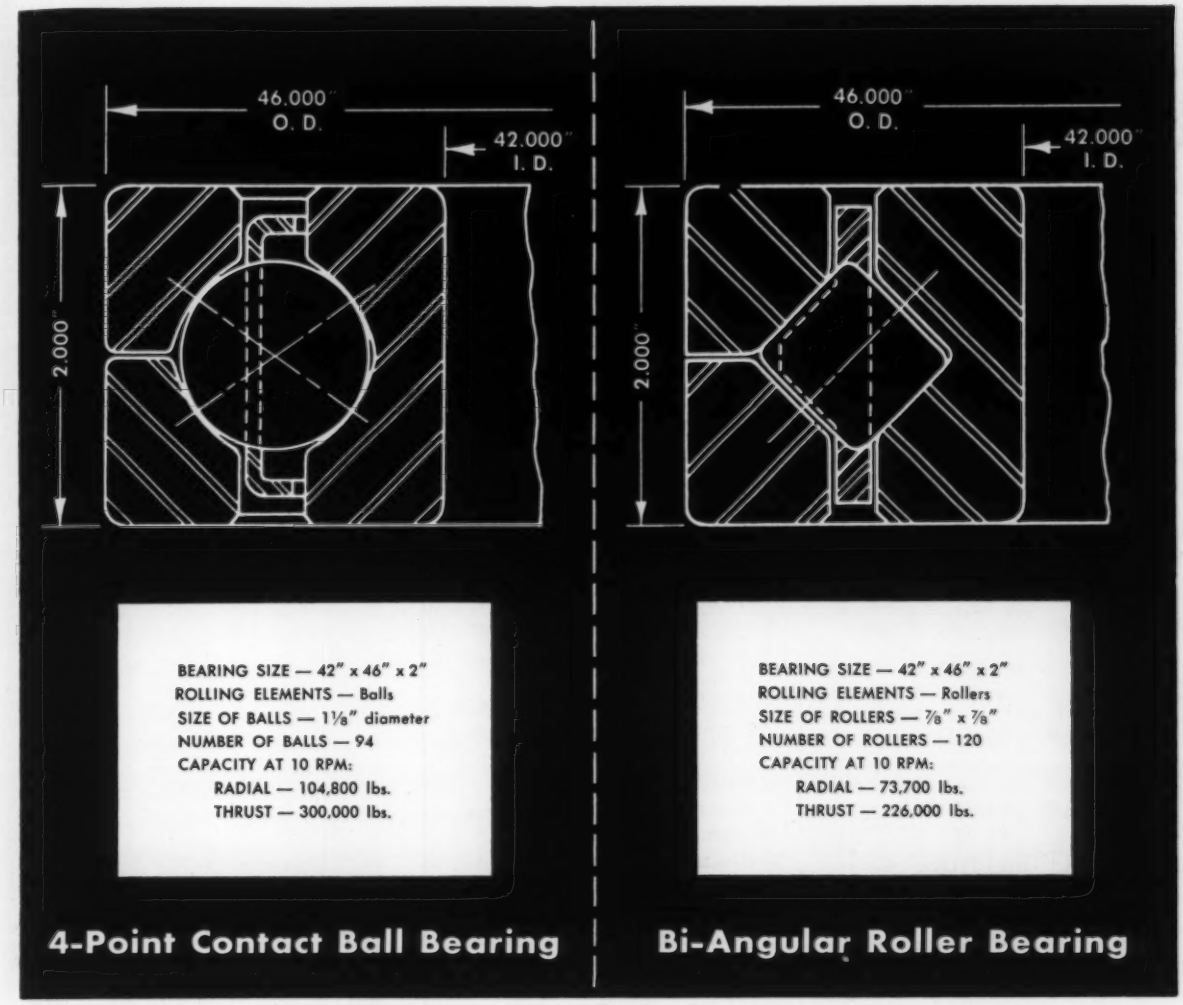


SURE we make both, but we recommend only one

Yes, Kaydon manufactures both — 4-point contact ball and bi-angular roller bearings in the same diameters and widths. BUT—we would in almost every instance recommend the former. Why? Because our field application reports consistently prove that the 4-point contact ball bearings are better for most applications than the lower capacity bi-angulars *(See capacity figures in drawings above.)*

Another important difference between the two bearings is that the 4-point contact ball bearing *is not limited to low speeds*, whereas the bi-angular normally should not be used above 10 rpm and usually is suitable only for oscillation. Then, too, the torque in the 4-point contact ball bearings is generally much lower.

Kaydon's unbiased recommendations result from years of bearing design, application and manufacturing experience with *all types* of ball and roller bearings up to 124" in diameter. So, why not contact Kaydon first?

K-563

THE KAYDON ENGINEERING CORP.

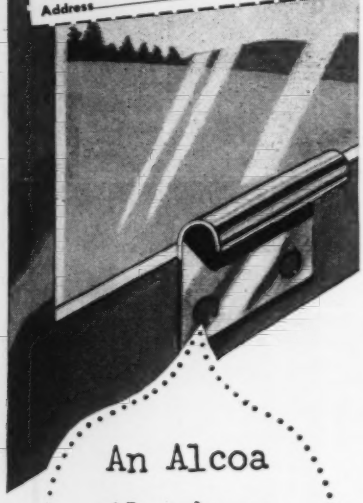
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter... Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 514 on page 19

FILL OUT COUPON
FOR FACTS, SAMPLES

ALUMINUM COMPANY
OF AMERICA
2244-J Alcoa Bldg., Pittsburgh 19, Pa.
Gentlemen:
Please send complete specification data and samples of your aluminum fasteners.
Name
Title
Company
Address



An Alcoa Aluminum Fastener should be used here!

It's an aluminum window lift assembly, worth the lasting strength of Alcoa® Aluminum Fasteners. You avoid galvanic and atmospheric corrosion. You get perfect color match; you get the very highest quality product. Your local Alcoa distributor has a complete stock.

P. S. In this window lift assembly, we suggest an aluminum 78° countersunk rivet. One of Alcoa's complete line of aluminum fasteners.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

YOUR GUIDE TO THE BEST IN ALUMINUM VALUE

ALCOA ALUMINUM FASTENERS

Circle 515 on page 19

(*Continued from Page* 15)

Typical suggested applications for silver-magnesium-nickel alloys are: Electrical contacts which can be attached by brazing without loss of hardness; shields and clips for miniature vacuum tubes requiring excellent thermal conductivity; instrument and relay springs, contact arms, wipers and sliders requiring high conductivity and hardness at elevated temperatures.

One-Pound, Two-Way Radio Fits in Combat Helmets

FORT MONMOUTH, N. J. — The Army Signal Corps recently announced a combat helmet radio that lets GI's talk to each other —through their hats.

Like the heavier walkie-talkie, this new radio is battle-rugged and allows two-way conversations. It was developed by the Signal Corps Engineering Laboratories to bring radio communication to individual riflemen for the first time. The set weighs only 1 lb and was made smaller than two packs of cigarettes by the use of transistors.

The new set fits inside an experimental helmet made of synthetic material that is claimed to protect the head as effectively as steel.

To prevent enemy interception of messages, the helmet radio is preset for short-range conversations. On short notice, the range can be greatly increased by attaching an auxiliary antenna to the top of the helmet.

At full capacity, the set can reach other radios up to a mile away and can hear powerful stations at even greater distances. It operates continuously for a half-day on a single set of tiny batteries.

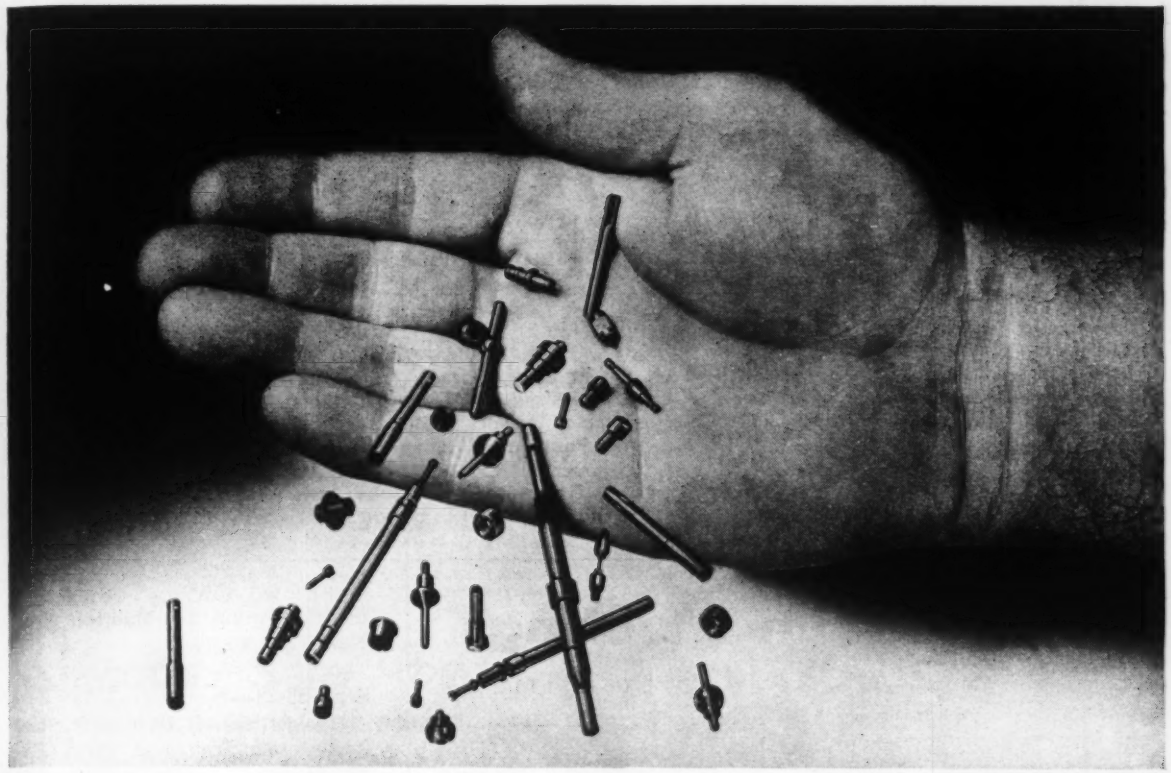
To answer a call, the soldier merely flips a switch and talks into a microphone about the size of his thumb. No warm-up time is needed. When talking might give away his position, the GI can push a second button at the side of the helmet, and acknowledge a message with a short radio "beep."

Assembly line models are expected to be practically indestructible. The set is designed to work even after being dropped 5 ft onto a concrete floor, tumbled 5 hr in a bouncing machine, and battered with an impact equal to flying shrapnel.

Talking through his hat, this soldier uses the Army's new individual radio. The helmet radio weighs 1 lb and operates a half-day on one set of batteries.

U. S. Army photographs

Helicopter speed record of about 160 mph has been "unofficially" exceeded by the McDonnell XV-1 convertiplane, which reached a speed of 200 mph in a recent flight. The XV-1, which is equipped with wings, takes off and lands like a helicopter, powered by three pressure jet engines on its rotorblades. In-flight conversion to propulsion by a conventional aircraft piston engine makes possible the higher rate of speed.



Do small parts like these give you large problems?

Anaconda Rod solved costly production problems for G & F Manufacturing Company, Philadelphia

The trend toward miniatures has led to a tremendous increase in the use of small precision parts like these. And this has placed a heavier burden on the screw machine operator and the buyer of rod. Uniformity of alloy and dimension in batch after batch of screw machine rod is vital for economical production.

ONE COMPANY'S PROBLEM: The G & F Manufacturing Company of Philadelphia specializes in automatic screw machine production of minute parts, finished to precise dimensions. This company was experiencing costly production delays with the rod they were using, due to jamming and freezing of the rod as it was fed into the machines.

THE SOLUTION: Then G & F tried Anaconda Free Cutting Brass-271 Rod in the diameters required for their type of small-part production. They found it highly satisfactory. Down time, due to jamming or freezing of the rods, has been practically eliminated and production schedules are completed without costly interruption.

Whether for small parts of extreme accuracy—or for ordinary screw machine production—The American Brass Company can furnish free-cutting copper and copper-alloy rods fabricated to meet the requirements of the operation—uniform in length, diameter, temper and composition.

FREE TECHNICAL SERVICE: It is the function of the Technical Department of The American Brass Company to assist metal users in the solution of special problems. This service is at your disposal without charge or obligation.

Comprehensive data on composition and machinability of standard Anaconda Alloys, standard specifications, weights and dimensions of standard rods is available in Publication B-3. For this booklet—for special technical assistance—write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5662

ANACONDA® RODS FOR SCREW MACHINE PRODUCTS

Circle 516 on page 19

Just published!

FIRST IN THE FIELD
TO STRESS DYNAMICS
AND MACHINE DESIGN

CAMS

Design, Dynamics, and Accuracy

By HAROLD A. ROTHBART,
College of the City of New York

This new work is the first on cams to go beyond simple drafting techniques. Exceptionally wide in scope, it offers a thoroughly modern treatment of dynamics and machine design, using cams as a basis, and represents a significant extension of the usual kinematic approach to cam action.

Both the theoretical and practical aspects are thoroughly covered. On the practical side, the author makes concrete recommendations concerning such topics as mass, acceleration, materials, and the type of cam and follower to be used. The discussion of profile accuracy and errors, will prove especially informative. Mathematics is kept at a minimum throughout the presentation.

The book fills a vital need in machine design, in the light of today's current trends toward high-speed machinery, automation, mechanical computers, and servo-mechanisms.

1956 350 pages 210 illus. $9.50

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440 Fourth Ave., New York 16, N.Y.

Please send me CAMS, to read and examine ON APPROVAL. In 10 days I will return the book and owe nothing, or will remit $9.50, plus postage.

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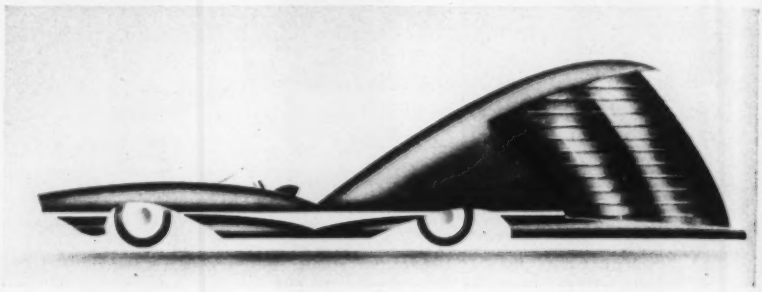
Circle 517 on page 19

Engineering News Roundup



TALL TAIL might make a dream car of the future look like this if the trend to increase the size of plastic tail lights continues. Pleasing as the prospect might be to plastics manufacturers, the sketch was presented by Bill Wall of Du Pont only as humorous relief at the recent 129th annual meeting of the American Chemical Society. In a more serious vein, Wall reported that the typical 1956 automobile uses plastics in 105 applications but the total weight is only 10 lb per car.

Meetings

AND EXPOSITIONS

Sept. 23-26—

American Society of Mechanical Engineers. Petroleum - Mechanical Engineering Conference to be held at the Statler Hilton Hotel, Dallas, Tex. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 24-25—

Fifth Annual Industrial Electronics Symposium to be held at the Manger Hotel, Cleveland. Sponsors are Institute of Radio Engineers and American Institute of Electrical Engineers. Further information can be obtained from R. C. Rodgers, Associate Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Sept. 24-25—

Steel Founders' Society of America. Fall Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

Sept. 24-28—

Trade Fair of the Atomic Industry to be held at the Navy Pier, Chicago. Additional information can be obtained from Atomic Industrial Forum, 260 Madison Ave., New York 16, N. Y.

Sept. 25-28—

Association of Iron and Steel Engineers. Iron and Steel Exposition and Convention, to be held in the Public Auditorium, Cleveland. Additional information can be obtained from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 1-3—

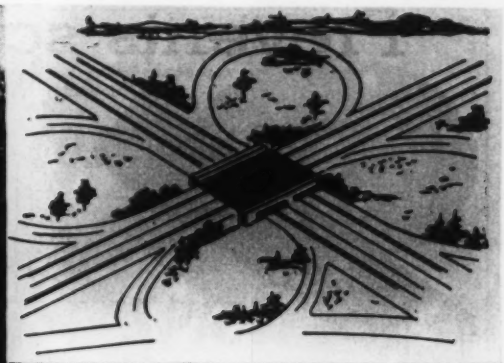
National Electronics Conference and Exhibition to be held at the Hotel Sherman, Chicago. Sponsors are American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University and University of Illinois. Further information is available from conference headquarters, 84 E. Randolph St., Chicago 1, Ill.

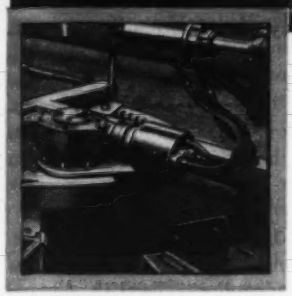
Oct. 8-10—

American Society of Mechanical Engineers. ASME-ASLE Third Lubrication Conference to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Oct. 8-12—

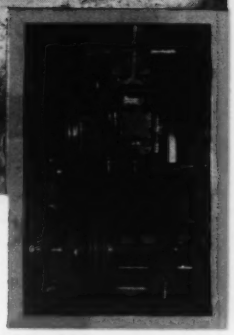
National Metal Congress and Exposition to be held at the Public Auditorium, Cleveland. Participants in the scientific sessions will be the American Society for Met-





GALION 104 Motor Grader, above, uses Eastman Assemblies on *EIGHT* Hydraulic controls for more accurate, effortless and economical grading. Close-up, left, shows powerful Hydraulic Circle Turn for famous Galion "Reversible" Moldboard.

BARBER-GREENE Bituminous Finisher, right, automatically lays level finish for smoother, safer travel. Close-up shows Eastman Hydraulic Hose Assembly delivering 2,700 lbs. pressure to raise and lower finishing screed.



Smoother, Safer Roads

BUILT WITH HYDRAULIC POWER

DELIVERED THROUGH

Eastman

HYDRAULIC HOSE ASSEMBLIES

ALWAYS SPECIFY

EASTMAN Pressed-on, Reusable and Renewable Couplings for high and low pressure air, gas, water, paint, grease and hydraulic fluids. Eastman Straight and Angled Adapter Unions.

Smoother, safer highways are being built today through the application of modern engineering and the use of modern equipment—much of which is hydraulically operated—using Eastman Hydraulic Hose Assemblies.

GALION—pioneer builder of road machinery—whose Motor Graders and Rollers are used 'round the world—first used hydraulic controls as early as 1927. Eastman Mfg. Co. pioneered in the development of Hydraulic Hose Assemblies in 1926—and *Galion is Eastman equipped today!*

BARBER-GREENE—whose Bituminous Road Finishers have been used at one time or another on almost every road ever built—also uses Eastman Hydraulic Hose Assemblies. Hydraulic power is used to raise and lower the all-important mechanism which lays a level finish—regardless of irregularities in the base. Barber-Greene's founding date of 1916 closely parallels Eastman's of 1914—and *Barber-Greene is Eastman equipped today!*

EASTMAN—*first in the field*—is proud to have pioneers such as Galion and Barber-Greene—as well as many other leading American manufacturers—use Eastman Hydraulic Hose Assemblies. Look to Eastman for *continued leadership* in engineering and design for quality of material and workmanship—plus better-than-ever service through expanded production facilities of our new, modern plant.

SAFEGUARDING INDUSTRY'S *Lifelines of Mobile Power*

Eastman

first in the field

MANUFACTURING COMPANY

Dept. MD-9 Manitowoc, Wis.

WRITE **for Eastman Catalog or send blueprints stating your hydraulic requirements and specifications.**

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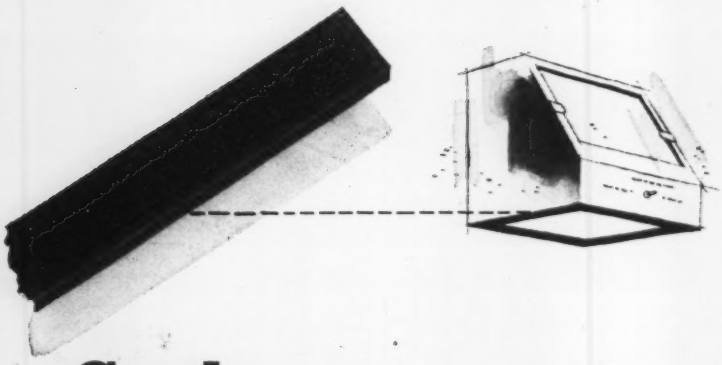
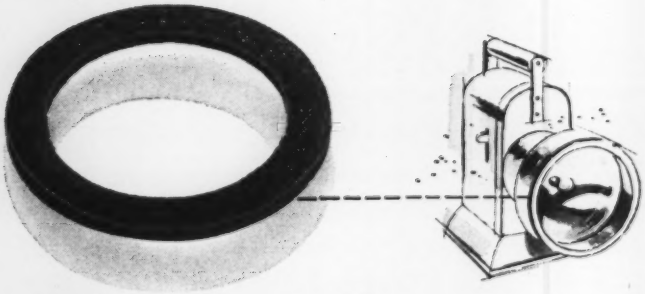
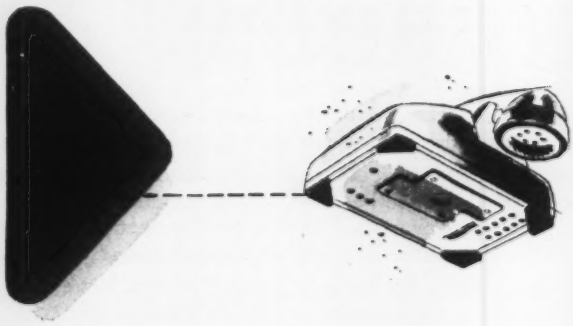
Prevents scratches



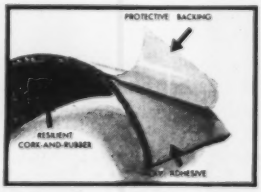
Seals



Skidproofs



Armstrong DK-153 is a resilient cork-and-sponged-rubber composition backed with pressure-sensitive adhesive. This versatile material is now being used for hundreds of different industrial jobs. For example, DK-153 keeps equipment from scratching table tops, keeps moisture and dirt out of electric lanterns, and keeps telephones from slipping on polished desks. You can get DK-153 in rolls, strips, sheets, or die-cut shapes in thicknesses from 1/32″ to 3/16″. In any form, DK-153 is easy to apply: just peel off protective covering and press material into place. For samples, write Armstrong Cork Co., Industrial Div., 7309 Dean St., Lancaster, Pa.



Armstrong DK-153

. . . used wherever performance counts

Circle 519 on page 19

News Roundup

als; the American Welding Society; the Institute of Metals Div. of the American Institute of Mining, Metallurgical and Petroleum Engineers; and the Society for Non-Destructive Testing. Additional information can be obtained from show headquarters, 7301 Euclid Ave., Cleveland 3, O.

Oct. 10-12—

Society of Automotive Engineers. National Transportation Meeting to be held at Hotel New Yorker, New York. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Oct. 18-19—

National Conference on Industrial Hydraulics. Twelfth Annual Meeting to be held at the Sherman Hotel, Chicago, sponsored by Illinois Institute of Technology. Further information can be obtained from Joseph J. Kowal, Conference Secretary, Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Oct. 18-20—

Foundry Equipment Manufacturers Association Inc. Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Further information can be obtained from association headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 20-23—

Conveyor Equipment Manufacturers Association. Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. More data can be obtained from association headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 22-24—

Purdue University. First Conference on Manufacturing Automation cosponsored by *Automation* Magazine. Additional information may be obtained from Editor, *Automation,* Penton Building, Cleveland 13, Ohio.

Oct. 22-26—

National Industrial Exposition

and Management Conferences to be held at the Artillery Armory, Detroit. Additional information can be obtained from A. F. Denham, Exposition Director, 927 Book Bldg., Detroit 26, Mich.

Oct. 24-25—

American Society of Mechanical Engineers. ASME-AIME Joint Fuels Conference to be held at Sheraton Park Hotel, Washington, D. C. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Oct. 25-26—

Aircraft Electrical Society. Annual display of aircraft electrical equipment to be held at the Pan-Pacific Auditorium, Los Angeles. Further information can be obtained from society headquarters, 930 S. Robertson Blvd., Los Angeles 35, Calif.

Oct. 28-31—

American Gear Manufacturers Association. Semiannual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information can be obtained from association headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 30-Nov. 1—

National Fluid Power Association. Fall Meeting to be held at the Hotel Cleveland, Cleveland. Further information can be obtained from association headquarters, 1618 Orrington Ave., Evanston, Ill.

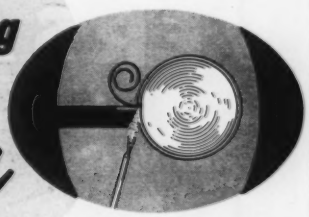
Oct. 30-Nov. 2—

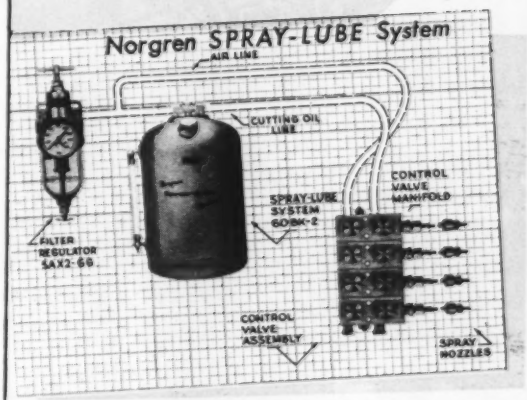
Gray Iron Founders Society Inc. Annual Meeting to be held at The Homestead, Hot Springs, Va. Additional information is available from society headquarters, National City—E. Sixth Bldg., Cleveland 14, O.

Oct. 31-Nov. 2—

Society for Experimental Stress Analysis. Annual Meeting and Exhibit to be held at the Deshler-Hilton Hotel, Columbus, O. Further information can be obtained from society headquarters, P. O. Box 168, Cambridge 39, Mass.

Faster Metal Cutting at LOWER COST with improved Norgren SPRAY-LUBE



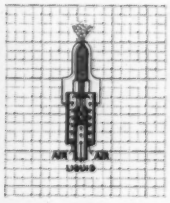


for
Tapping Machines
Drill Presses
Milling Machines
Grinders
Lathes
Boring Machines
High-Speed Saws
Stamping Presses
Die Lubrication
Other Metal Working Equipment

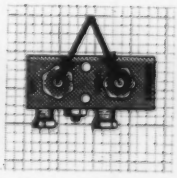
Better Lubrication—A better, more uniform spray of cutting oil is applied directly upon the close interface between the tool and work piece. Tool wear is less—saves tool costs, cuts down-time.

Faster Cooling—Because of the larger fluid surface area of the spray and the expansion of the compressed air, heat is dissipated quicker. Cutting can be faster—production stepped up.

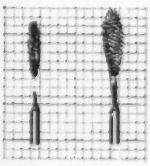
Uniform Spray
Air and cutting oil, with flow of each accurately controlled, are conveyed to the nozzle by means of a tube within a tube connection.



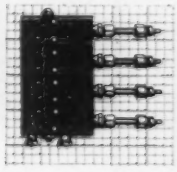
Tamper-Proof Controls
Allen-head screws are used on the control valves for adjusting flow of both air and liquid.



Accurate Control of Spray
By adjusting the pressure and the individual outlet controls for air and coolant, spray can be applied in exactly the right quality and quantity for any metal cutting or metal forming job.



Valves Compactly Manifolded
For multi-point application of SPRAY-LUBE, the control valves are designed so that they can be closely assembled in a manifold arrangement.



Compact, Convenient Size
A space only 14"x20"x7" is required for a 2-gallon unit—4 to 12 fluid ounces of liquid an hour per nozzle are sufficient for most operations.

Norgren CA CO
3442 So. Elati St., Englewood, Colo

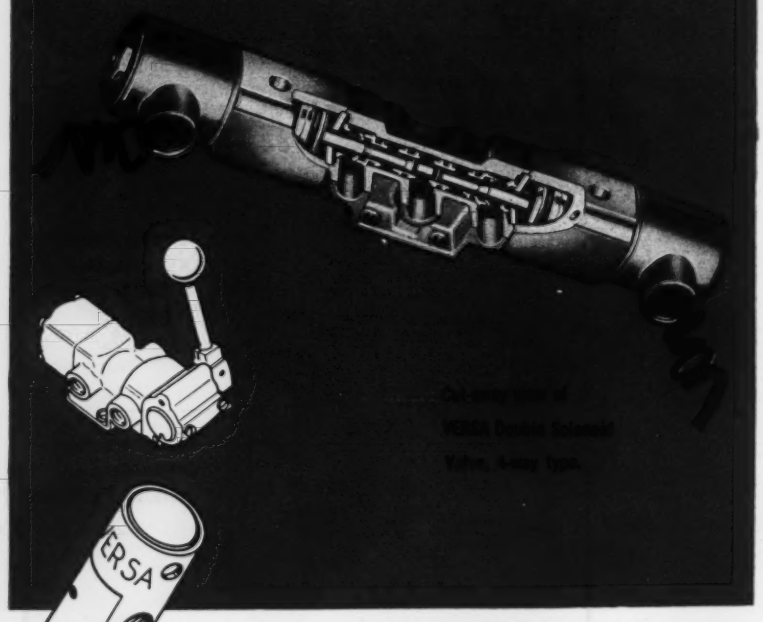
Without obligation, learn how improved Norgren SPRAY-LUBE can reduce costs in your plant. Call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BULLETIN 537.

Pioneer and Leader in Oil-Fog Lubrication Since 1930

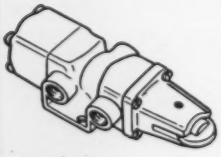
Circle 520 on page 19

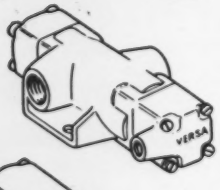
VERSA Control Valves

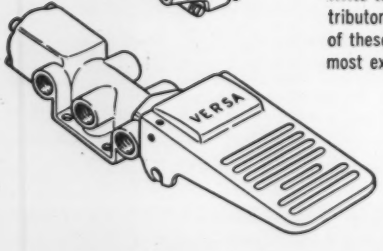
FOR IMMEDIATE DELIVERY...



in Over 110,000 Variations!







Versa Valves are available in 2-, 3-, 4-, and 5-way types with over 20 actuating devices, in sizes from ⅛" to 1" N.P.T., and for pressures from partial vacuum to 500 PSIG.

The entire line of Versa Valves (over 110,000 variations) are stocked by authorized Versa distributors, strategically located throughout the United States and Canada.

All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness . . . actually exceed J.I.C. standards.

Write today for the name of your nearest Versa distributor. Remember, you can get immediate delivery of these rugged, compact control valves to fit your most exacting hydraulic or pneumatic requirement.

The entire line of VERSA Valves is explained in our new comprehensive Folder #14

VERSA

VERSA PRODUCTS COMPANY INC.
247 SCHOLES STREET
BROOKLYN 6, N. Y.

Circle 521 on page 19

MEN
OF MACHINES

W. W. Higgins has been appointed chief engineer of the A. O. Smith Corp., Milwaukee. Mr. Higgins was director of engineering at the corporation's Permaglas Div.

W. W. Higgins

in Kankakee, Ill. He joined the company at Milwaukee in 1930 and transferred to the Permaglas Div. in 1946 as director of quality control and inspection. He was named chief engineer in 1948 and director of engineering in 1952.

W. L. Komph has been elected vice president of the Anker-Holth Div. of Wellman Engineering Co. The division is located in Port Huron, Mich. Mr. Komph joined Anker-Holth in 1947 as assistant engineer.

The Axle Div. of Clark Equipment Co., Buchanan, Mich., recently appointed **L. M. Gray** chief engineer, **G. C. Vanderberg** engineering consultant, and **William E. White** development engineer. Mr. Gray, who joined Clark in 1925, was previously assistant to the chief engineer. Mr. Vanderberg, associated with the company since 1919, had been chief engineer of the division since 1937. Mr. White

has served as product engineer in charge of brake specification and design for all Clark divisions.

Robert O. Fehr has been appointed manager of the Mechanical Engineering Laboratory of General Electric Co., Schenectady, N. Y. Dr. Fehr joined the company's General Engineering Laboratory in 1939. He was named a section engineer in 1947, supervising studies in acoustics, vibration and stress analysis. He was appointed consulting engineer in this field in 1952.

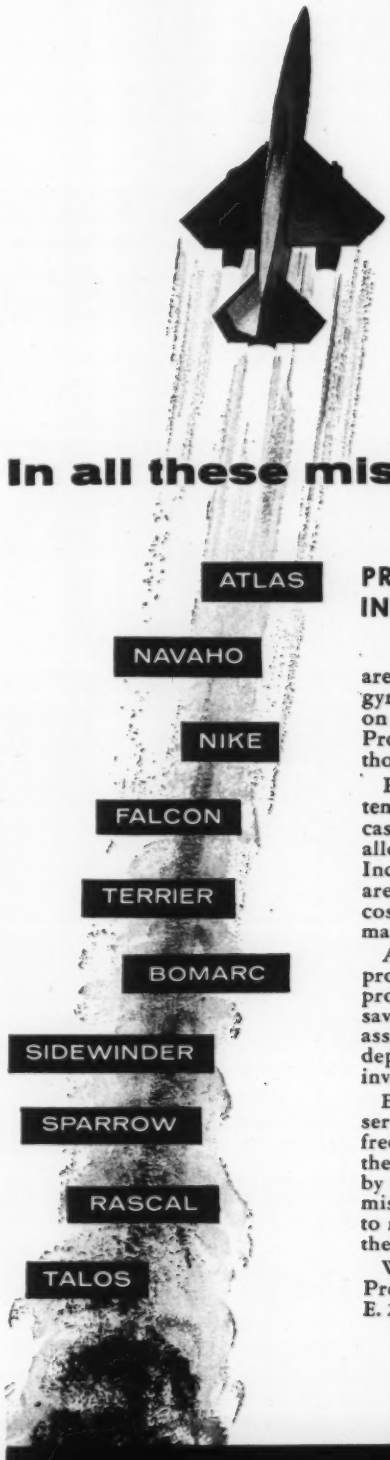
Copeland Refrigeration Corp., Sidney, O., recently named **E. R. Boynton** chief engineer and Oskar H. Buschmann vice president of engineering.

Daniel T. Sigley has been appointed chief engineer for the Guided Missile Div. of Firestone Tire & Rubber Co. of California, Los Angeles. He was formerly

Daniel T. Sigley

chairman of the Guided Missile Steering Committee and associate director of the General Engineering Laboratories for American Machine & Foundry Co. At Firestone Dr. Sigley will direct electronic and mechanical engineering on advanced weapon systems.

Gladden Products Corp., Glendale, Calif., has announced the appointment of **Keith Sorenson** as



In all these missile programs

PRECISION METALSMITHS' INVESTMENT CASTINGS . . .

are being used in the power plants, gyro- and servo-mechanisms, and on various other types of equipment. Production orders may run into thousands of pieces or as few as desired.

Parts that must resist the terrific temperatures encountered are being cast in the excellent heat-resistant alloys like Hastelloy, Stellite and Inconel. Ferrous and non-ferrous alloys are investment cast in shapes too costly to fabricate by other manufacturing methods.

As a result of using this process for producing a part, the fabrication process is simplified and sizable cost savings are made. In contrast with assemblies, greater uniformity and dependability are often obtained with investment castings.

By taking advantage of our prototype service, the product designer can give free rein to his imagination. To get the most out of your designs and profit by our extensive experience on these missile programs, ask our engineers to review them while they're still in the planning stage.

Write for our "Prototype Literature". Precision Metalsmiths, Inc., 1083 E. 200th Street, Cleveland 17, Ohio.

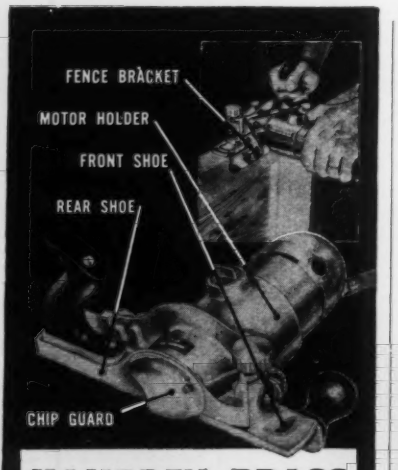
See us in Booth 1830 at the Metal Show

pour yourself an assembly with

PRECISION METALSMITHS INC.

INVESTMENT CASTINGS

Circle 522 on page 19



HAMPDEN BRASS
Die Castings have cleaner, smoother surfaces
Machining operations reduced to a minimum on
STANLEY Power Plane

Hampden Brass's engineering department and the Stanley Electric Tool Division worked together to design the H33 Power Plane castings. These aluminum die-cast parts reduce machining time to a minimum. Each casting is of uniform thickness throughout, and all meet high quality standards in production quantities. Hampden Brass solved the problem of intricate coring and thin walls of the front and rear shoe, and the mating surfaces were used as cast . . . eliminating machining at the V-slide match. The result: quality die castings that fulfill every requirement at lower-per-unit cost.

Let HAMPDEN BRASS Help You Solve Your Casting Problems!

Avail yourself of our engineering counsel . . . or write for a casting quotation today!

Send for brochure, "Behind the Scenes" . . . complete digest of Hampden Brass's experience, equipment and facilities.

HB

HAMPDEN BRASS
AND ALUMINUM CO.
Established 1903
262 Liberty St.•Springfield, Mass.
Producers of Sand, Permanent Mold, Die & Fiberglas Castings

Circle 523 on page 19

vice president and general manager of Motronics Corp., a wholly owned subsidiary.

James R. Nolan has been appointed manager of the research and development department of Fort Worth Steel & Machinery Co., Fort Worth, Tex. Mr. Nolan has been engaged in product development work at Convair's Fort Worth division for the last seven years. Previously he was product development engineer for Hobbs Mfg. Co. and had also been associated with Curtiss-Wright Corp. and Waco Aircraft Corp.

James R. Nolan

Littleford Bros. Inc., Cincinnati, has appointed **William T. Camm** chief of the design and development department and **T. J. Grueter** design and development engineer.

As a result of a recent merger, the Lincoln Engineering Co. of St. Louis is now known as Lincoln Engineering Co., Div. of McNeil Machine & Engineering Co. **Carl H. Mueller,** former vice president of engineering for Lincoln, remains in charge of this department as director of engineering.

Glenn E. Seidel has been appointed to the newly created position of vice president in charge of engineering for Minneapolis-Honeywell Regulator Co., Minneapolis. Mr. Seidel has been a member of the company's engineering organization for approximately 14 years and since 1952 has been vice president in charge of engineering for the Minneapolis plants.

American Hoist & Derrick Co., St. Paul, has appointed **J. J. Hite** director of engineering, **William Niessen** chief structural engineer, and **Kenneth Porter** chief mechanical engineer.

Carl Halpin has been appointed manager of engineering at Ross Operating Valve Co., Detroit. Mr. Halpin formerly was president of the F. L. Jacobs Co. and has also been associated with the Fisher Body Div. plant, Fruehauf Trailer Co. and Baker Perkins Inc.

International Resistance Co., Philadelphia, has appointed **Sava Sherr** chief mechanical engineer. He was formerly president of Stanley Industries Inc.

George E. James has been appointed director of a newly established research, development and technical liaison activity of the Ramo-Wooldridge Corp. in Boston. Mr. James was formerly chief engineer at the Laboratory for Electronics Inc.

W. C. Heath has been named projects manager of the San Diego plant of Solar Aircraft Co. Mr. Heath will be responsible for initiating and co-ordinating activities pertaining to major projects in the various company divisions. He has been associated with Solar since 1937.

Cornelius J. Hes and **Michael Panich** have been appointed assistants to the manager of the engineering department of Bailey Meter Co., Cleveland. Mr. Hes will be in charge of special design and Mr. Panich will be in charge of product design.

Edward C. Wagner has been appointed director for marine equipment by Ford Instrument Co., Div. of Sperry Rand Corp., New York. Mr. Wagner was formerly department head for gunnery equipment.

NEW! COMPACT! RUGGED!

One low-speed gear set per drive size and maximum accessibility of all operating parts simplifies maintenance.

Design of drives permits the addition of integral, positive-locking backstop at any time.

Built-in alignment results from use of rabbet-fit motor flange.

One-piece cast iron housing is rugged, oil-tight and assures quiet operation.

LINK-BELT GEARMOTORS

maintain positive alignment with flange-mounted NEMA motors . . .

Dependable alignment, long-lasting efficiency and quiet, oil-tight operation — every quality that constitutes top drive performance is built into modern Link-Belt Gearmotors. New design concepts with improved construction and latest manufacturing methods provide maximum economy, minimum maintenance in heavy-duty service.

Choose a Link-Belt Gearmotor up to 30hp, speeds from 280 down to 6 rpm. Contact your nearest Link-Belt office or authorized stock-carrying distributor today.

Ask for new 28-page Book 2447—offering interesting design highlights and complete engineering data.

LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,900

Link-Belt has also developed a new line of Motogears for bracket-mounting NEMA motors, with such outstanding features as quick motor replacement, straddle-mounted pinion and other advantages essential to continuous service under shock, reversing and heavy loads.

Circle 524 on page 19

LINDBERG INDUCTION UNIT IMPROVES HEAT TREATING PROCESSES AT J.I. CASE...

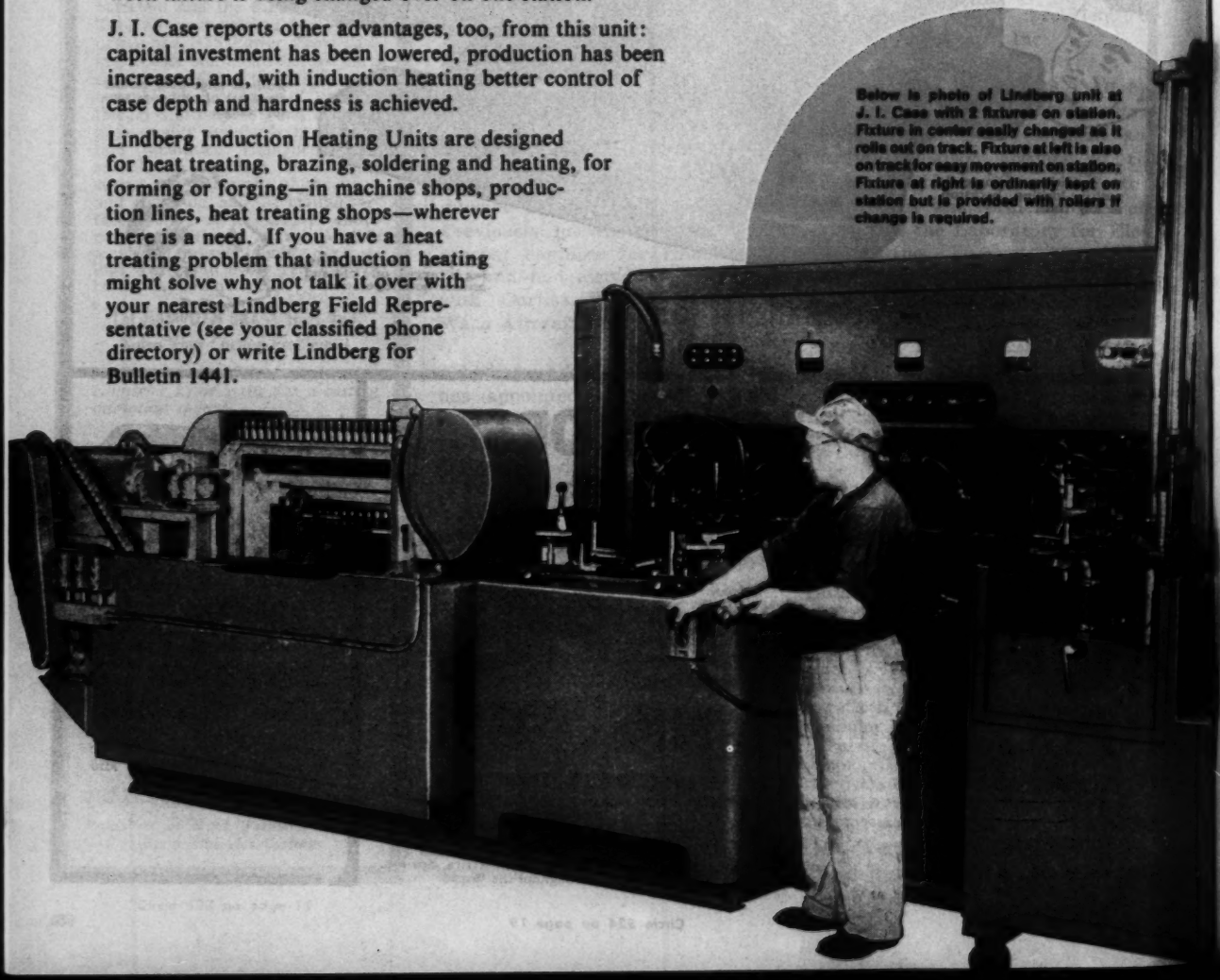
SAVES ½ ITS TOTAL COST— IN 1 YEAR!

A single Lindberg 2-station High Frequency Induction Heating Unit at J. I. Case Co., Racine, Wisc., is providing a happy combination of sizeable cost savings and improved quality and production efficiency in heat treating parts for Case tractors. Actually, the dollar savings effected with this Lindberg unit will repay its total original cost in *less than 2 years!*

This single unit and the five work fixtures provided with it, working on 2 to 3 shifts, 5 days a week to meet production requirements, heat treat some 63 separate tractor parts. Work fixtures are readily changeable, set-up time is materially reduced, and because of the 2-station design, the unit can operate continuously while work fixture is being changed over on one station.

J. I. Case reports other advantages, too, from this unit: capital investment has been lowered, production has been increased, and, with induction heating better control of case depth and hardness is achieved.

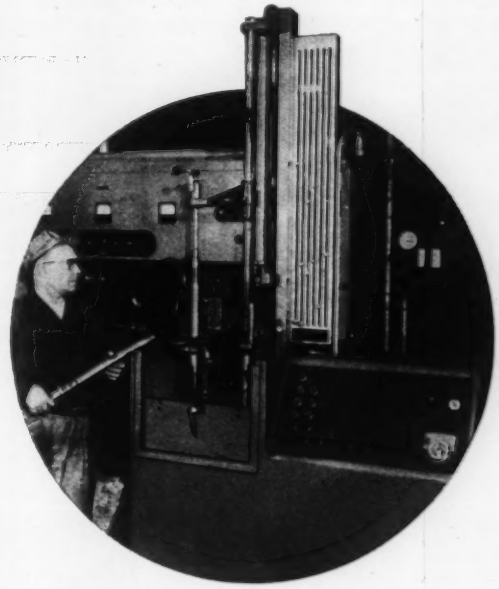
Lindberg Induction Heating Units are designed for heat treating, brazing, soldering and heating, for forming or forging—in machine shops, production lines, heat treating shops—wherever there is a need. If you have a heat treating problem that induction heating might solve why not talk it over with your nearest Lindberg Field Representative (see your classified phone directory) or write Lindberg for Bulletin 1441.



Below is photo of Lindberg unit at J. I. Case with 2 fixtures on station. Fixture in center easily changed as it rolls out on track. Fixture at left is also on track for easy movement on station. Fixture at right is ordinarily kept on station but is provided with rollers if change is required.

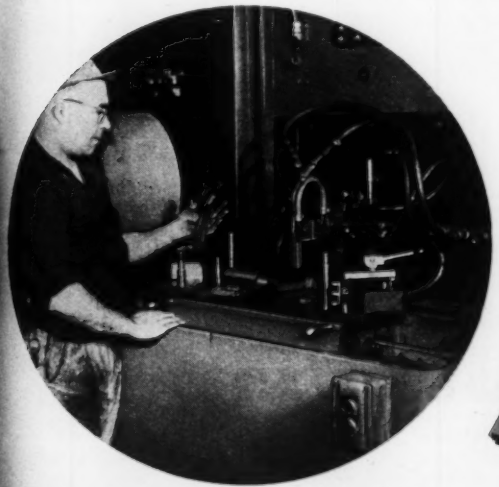
(Above) Hydraulic male coupling is being treated on this fixture. 3 other parts are treated by it, too.

(Below) This fixture is shown selectively hardening a front axle king pin. It handles piece up to 45⅛" long, 35" of which can be scanned to desired depth. It is also used for 34 other parts.



(Below) Power take-off hydraulic drive shafts are one of the 3 parts treated by this fixture.

(Above) This shows fixture handling inlet and exhaust valve rocker arms. Same fixture treats 6 other parts.

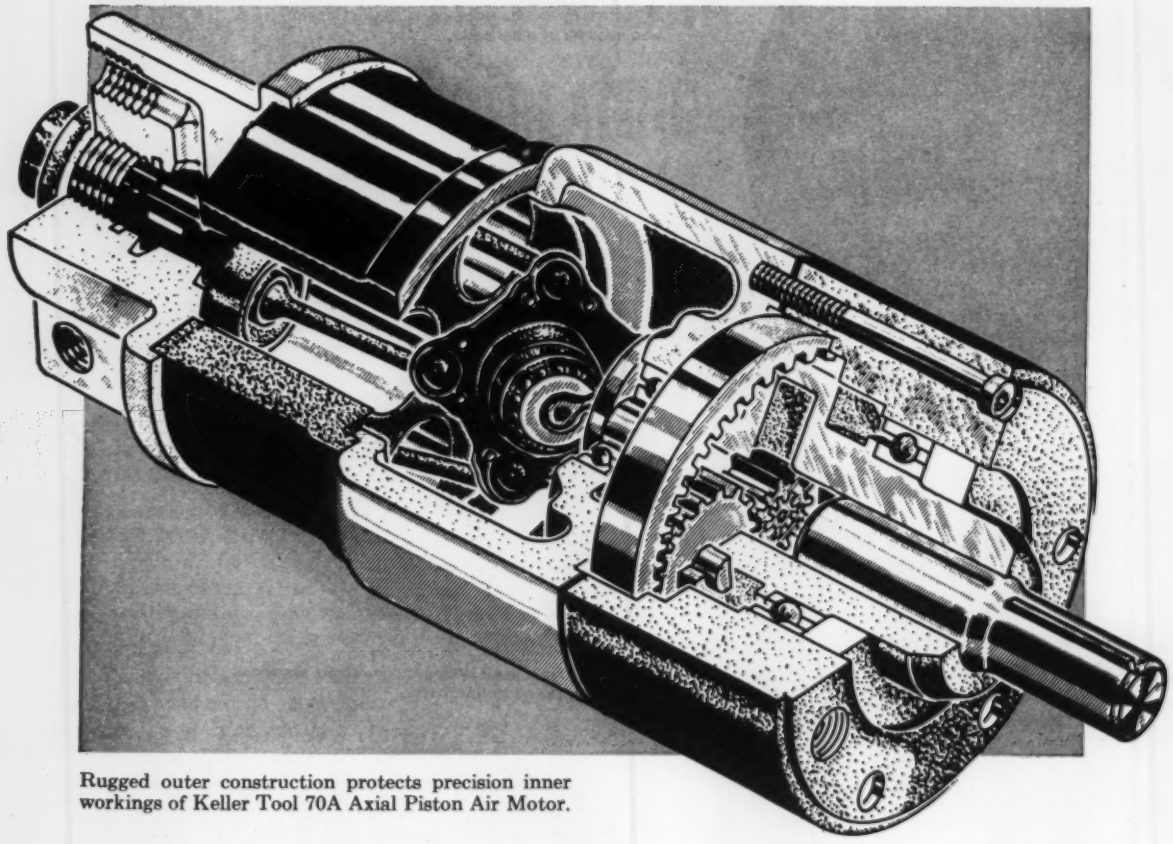


(Above) This fixture is selectively hardening pads and slots on shifter forks. It is also used for treating 17 other parts.

LINDBERG
HIGH FREQUENCY DIVISION
Lindberg Engineering Company
2473 West Hubbard St., Chicago 12, Ill.

Circle 525 on page 19

Gardner-Denver . . . Serving the World's Basic Industries



Rugged outer construction protects precision inner workings of Keller Tool 70A Axial Piston Air Motor.

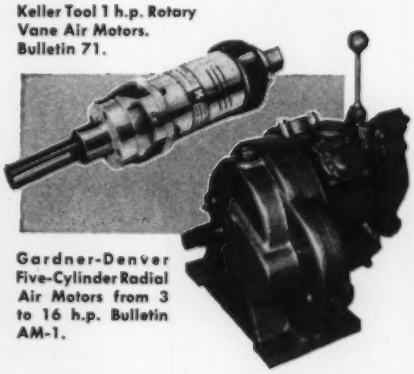
Inside information tells why Keller Tool air motor stars on tough assignments

Compact Design—Axial piston motor provides high torque and horsepower characteristics within compact dimensions.
No external spindle support needed—Generous size ball bearings safely accommodate heavy overhung load on spindle.
Face mounting—Three tapped holes assure positive mount without strapping. You position air connections for clean piping design.
Defy dust and corrosion—Enclosed construction permits use in contaminated environment. Motor withstands exposure to heat.
Operating characteristics—Instantaneous starts and stops . . . infinitely variable speed in either direction . . . non-sparking . . . cannot burn out when stalled . . . high torque at low speed . . . consistent stall torque, variable through air pressure regulation . . . efficient operation at high or low air pressure.

Send for Bulletin 70 today! It gives detailed specifications, dimensions and performance charts on 12 models of the Keller Tool Axial Piston Air Motor ranging from 0.6 to 2.7 h.p.

Other air motor favorites . . .

Keller Tool 1 h.p. Rotary Vane Air Motors. Bulletin 71.



Gardner-Denver Five-Cylinder Radial Air Motors from 3 to 16 h.p. Bulletin AM-1.

GARDNER - DENVER

KELLER TOOL division, Grand Haven, Michigan

THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Circle 526 on page 19

How a young designer made a hit with his Chief Engineer!

Problem: putting your lock washers on screws is costly and time consuming

WHAT TO DO?

How about hand assembling them before they reach the line?

WAIT A MINUTE! SEMS-by-SHAKEPROOF! They're mechanically pre-assembled!

Lock washer can't drop off but rotates freely for easy driving

The Shakeproof Lock Washer's twisted teeth give a positive locking action

Vibrations won't work 'em loose!

HOW ABOUT VARIETY?

Complete line of standards and Specials makes application unlimited!

Can be hopper fed too!

SEMS-by-SHAKEPROOF
Cut Costs
Save Time
Improve Quality

Send for FREE "Handy Sampler"

Write today for SEMS-by-SHAKEPROOF and informative "How-to-Choose" booklet.

SHAKEPROOF

"Fastening Headquarters"®

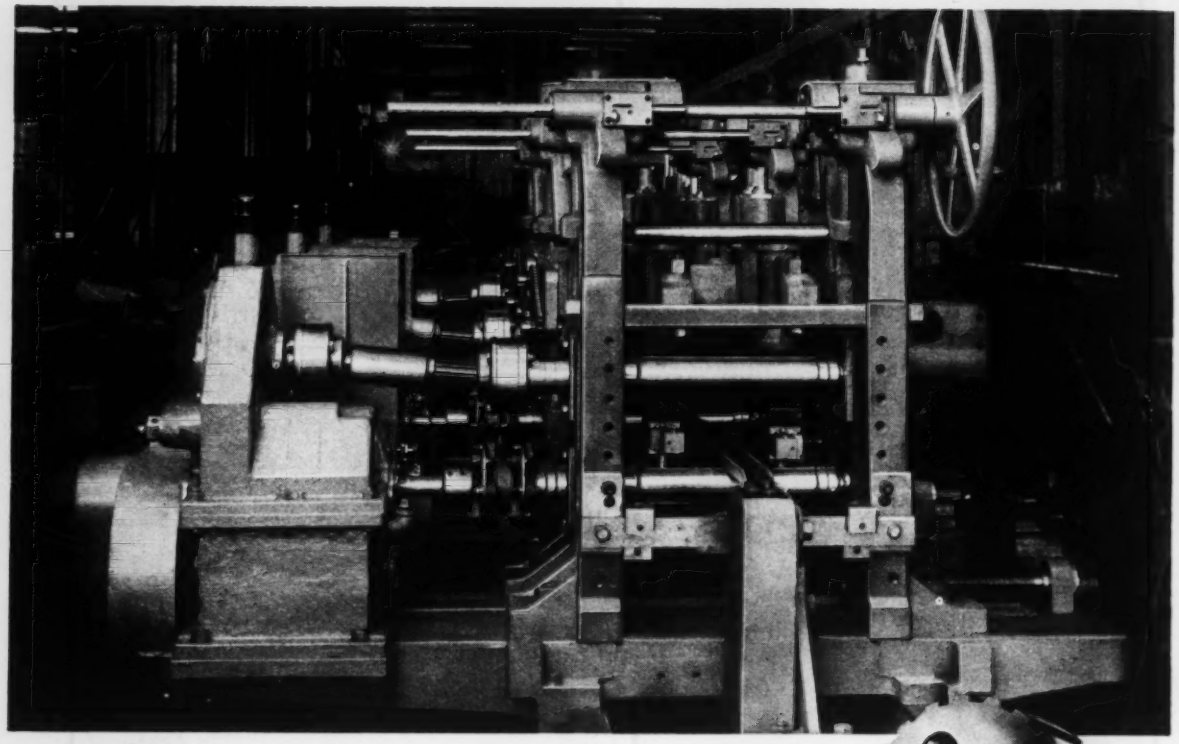
St. Charles Road, Elgin, Illinois • Offices in Principal Cities
In Canada: Canada Illinois Tools Limited, Toronto, Ontario

SHAKEPROOF
FASTEX

DIVISIONS OF ILLINOIS TOOL WORKS
World's Broadest Line of Mass-Assembly Fastenings

Circle 537 on page 19

How RZEPPA constant velocity universal joints help provide scratch-free aluminum extrusions



PROBLEM:

This equipment—built by the Sutton Engineering Company, Pittsburgh—is the answer to a problem common to processors of extrusions: how to correct cross-sectional distortions that occur in the extrusion and heat treatment of today's complex shapes.

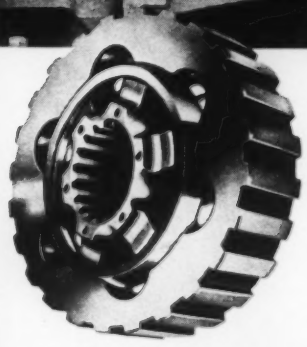
SOLUTION:

Sutton solved this problem with their new concept of giving accurately-proportioned torque to the top and bottom rolls through differential gearing.

Rzeppa Constant Velocity Universal Joints were added to overcome scratching and gouging caused by the irregular action of ordinary universal joints. Rzeppa Joints are giving scratch-free finishes even at extreme operating positions.

Other *modern design* advantages offered by Rzeppa include:

- INCREASED SPEEDS
- REDUCED DOWN-TIME
- LOWER MAINTENANCE
- HIGHER CAPACITIES



If you would like to know more about the outstanding capabilities of Rzeppa Constant Velocity Universal Joints, write today for your free copy of this complete, informative brochure.

RZEPPA SHEPPA

CONSTANT VELOCITY UNIVERSAL JOINTS

THE GEAR GRINDING MACHINE COMPANY

3937 CHRISTOPHER, DETROIT 11, MICHIGAN

MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES • THE DETROIT SCREWMATIC 750

Circle 528 on page 19

Circle 529 on page 19→

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 30

SILICONE DIELECTRIC COMPOUND LUBRICATES, STOPS CORROSION

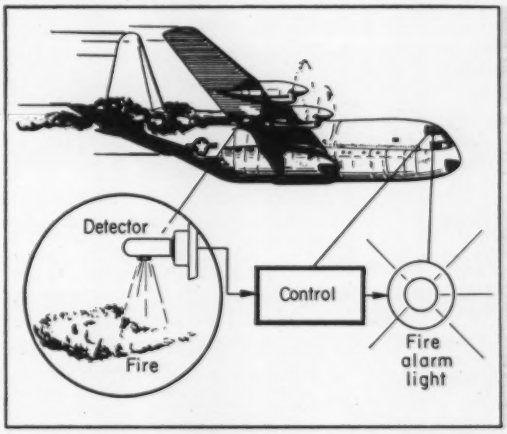
A silicone dielectric compound, Dow Corning 5 is growing in popularity for a wide variety of industrial and public utility applications. That's because the compound possesses excellent water repellency and corrosion resistance in addition to its superior dielectric properties.

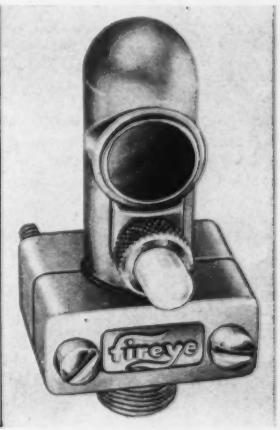
A leading public utility company reports a thin film of Dow Corning 5 on insulators reduces electrical leakage to a new minimum by preventing the formation of continuous, conducting moisture films.

Furthermore, the film maintains high surface resistivity despite heavy contamination by air-borne fly ash, cement dust and earth particles. Its effectiveness appears to persist without maintenance for many years.

Non-melting and grease-like, Dow Corning 5 is also an effective, long lasting

(*Cont. Pg. 2*)





SILASTIC PROTECTS AIRCRAFT FIRE DETECTOR FROM VIBRATION AND EXTREME TEMPERATURES

Retention of its dielectric and rubbery properties at temperatures ranging from —130 to over 500 F accounts for the growing popularity of Silastic* among designers working on products for extreme temperature operation. An excellent case in point is the new "Fireeye" fire prevention system developed for aircraft by Electronics Corporation of America, Cambridge, Mass.

Electronics engineers selected Silastic, Dow Corning's silicone rubber, to protect vital parts of the system because it is the only material that will maintain a dependable seal despite years of exposure to moisture, severe vibration and operating temperatures ranging from —65 to over 400 F.

The nerve centers of the "Fireye" system are highly-sensitive miniature photoconductive cells that automatically detect fire. To assure permanent sensitivity, these cells are partially potted and hermetically sealed with Silastic. Other components, too sensitive to withstand silicone rubber curing

*T.M.REG.U.S.PAT.OFF.

(*Cont. Pg. 2*)

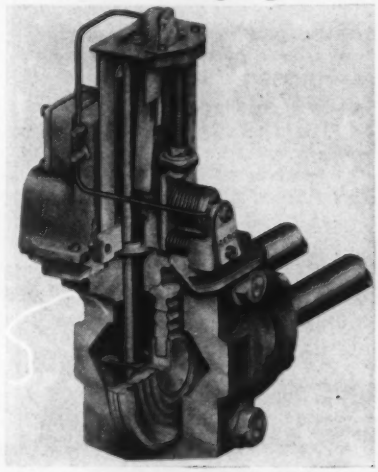
Product Designers Switch To Silicone Damping Fluids

Designers who have used Dow Corning 200 Fluid to dampen vibration, generally specify it for subsequent designs. For example, the new Foxboro Type 13A differential pressure Cell Transmitter is the most recent of several Foxboro units to contain 200 Fluid.

In place of the conventional single diaphragm, engineers at the Foxboro Company, Foxboro, Mass., adopted a twin-diaphragm capsule. Made up of two stainless steel diaphragms welded to a stainless steel core, the capsule is filled with Dow Corning 200.

The silicone fluid helps protect the diaphragms from overranges and permanent distortion. It also helps eliminate line disturbances ("noise") that otherwise interfere with flow measurements and have to be filtered out.

(*Cont. Pg. 2*)



CLASS H MOTOR STILL ON TEST AFTER 58,791 HOURS AT 240 C

At 10 A.M., June 6, 1946, a Class H insulated 10 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since it has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A.M. August 1, 1956, this motor was still on test after 58,791 hours at an average copper temperature of 240 C! That's equivalent to 358.5 years operation at the Class H temperature of 180 C.

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

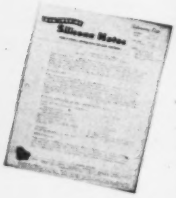
MORE

XUM

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . .



New booklet on Silicone Based Paints describes and illustrates how these heat, moisture, weather and oxidation resistant coatings improve product finishing and reduce maintenance costs on equipment ranging from industrial furnaces and exhaust stacks to domestic space heaters and garbage incinerators. Also explains difference between straight silicone and modified silicone paints now available from more than 50 formulators listed as sources of supply. *No. 305*

Documentary film "What's a Silicone?" available free of charge for showings to technical audiences in every industry. In full color and sound, this dramatic 16 mm film allows you to see Dow Corning silicones in action improving the performance of products ranging from nursing bottle nipples to diesel locomotives. For more information about this educational film and how to arrange a showing for interested persons in your plant, circle ----------*No. 306*

New engineering brochure featuring Silastic 50 and Silastic 80 is now available. A convenient reference, it includes detailed information on the physical and electrical properties of these two practical, general-purpose silicone rubbers. *No. 307*

Masonry water repellents made with Dow Corning Silicones give lasting protection to above-grade block, brick, concrete, stone, stucco and many other surfaces. Easily applied, such treatments do not discolor and help keep masonry clean by keeping water out—reducing efflorescence, cracking and spalling. New brochure now available provides complete information. *No. 308*

Antifoam B, a new silicone defoamer, has greater stability than any other water dilutable silicone foam-killer commercially available. Will not separate, oil out, plate out, settle or precipitate in most applications. Retains uniformity and effectiveness even if frozen or boiled. Ready to use, it eliminates need for diluting or pre-mixing. *No. 309*

NEW ANTI-FREEZE SYSTEM FOR STEAM AND WATER PIPE LINES UTILIZES SILASTIC R TAPE

Engineers at New Orleans Public Service, Inc., have recently completed installation of a unique system to supply auxiliary heat to 4000 feet of exposed steam and water lines at their A. B. Patterson station. In place of conventional steam tracers or resistance cables, a No. 16 copper wire, adjacent to the line is used to supply heat. Mineral insulated and sheathed in copper tubing, the wire is automatically energized when ambient temperatures drop below 40 F.

One technical difficulty that arose—the probability of galvanic corrosion between steel pipe and copper tubing—was conveniently solved by wrapping the entire length of steel pipe in Silastic* R Tape, a silicone rubber tape made by Dow Corning. The tape prevents direct contact between pipe and tubing.

Steam in the pipe converts the semi-cured silicone rubber tape into a permanent rubber-like and moisture-proof jacket. Possessing high thermal conductivity, the silicone rubber jacket diffuses heat to all areas of the pipe. The installation was completed by placing glass thermal insulation over the pipe and tubing. *No. 304*

*T.M. REG. U.S. PAT. OFF.

SILASTIC PROTECTS FIRE DETECTOR *(Continued)*

temperatures, are sealed with RTV Silastic, a room temperature vulcanizing silicone rubber.

Hundreds of military aircraft, including the Air Force's largest transports, the C-130 and C-133, already have "Fireye" protection. Thousands of hours of flight time have been logged without a failure. *No. 301*

SILICONE DAMPING FLUID *(Continued)*

Non-gumming and non-corrosive, Dow Corning 200 Fluid has a negligible vapor pressure and retains a near constant viscosity over the operating temperature span of the transmitter.

No organic fluid approaches Dow Corning 200 Fluid for uniformity of damping over a wide temperature span. For example, when temperatures increase from —40 to 160 F, the damping effect of silicone fluid decreases in the ratio of 3 to 1 compared to 2500 to 1 for organic oils. *No. 303*

DIELECTRIC COMPOUND *(Continued)*

lubricant for switches, meters, condensers, recorders and similar mechanisms. It maintains lubricity at temperatures ranging from —100 to over 300 F and resists moisture, oxidation, salt spray and chemical attack.

A convincing demonstration of the versatility of Dow Corning 5 is provided by Col. K. C. Brown (USAR Ret.) who reports that the silicone compound has stopped salt water corrosion of the tackle blocks, brass and copper fittings, electrical connectors and battery terminals on his ocean-going ship "Sou'Wester". In the Colonel's words, "The results far exceed expectations. Fittings and connections show no sign of corrosion; terminals are electrically efficient." *No. 302*

Dow Corning Corporation, Dept. 6809, Midland, Michigan

Please send me: 301 302 303 304 305 306 307 308 309

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COMPANY _____

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CITY _____ ZONE___ STATE_____

SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION

first in silicones

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MIDLAND MICHIGAN

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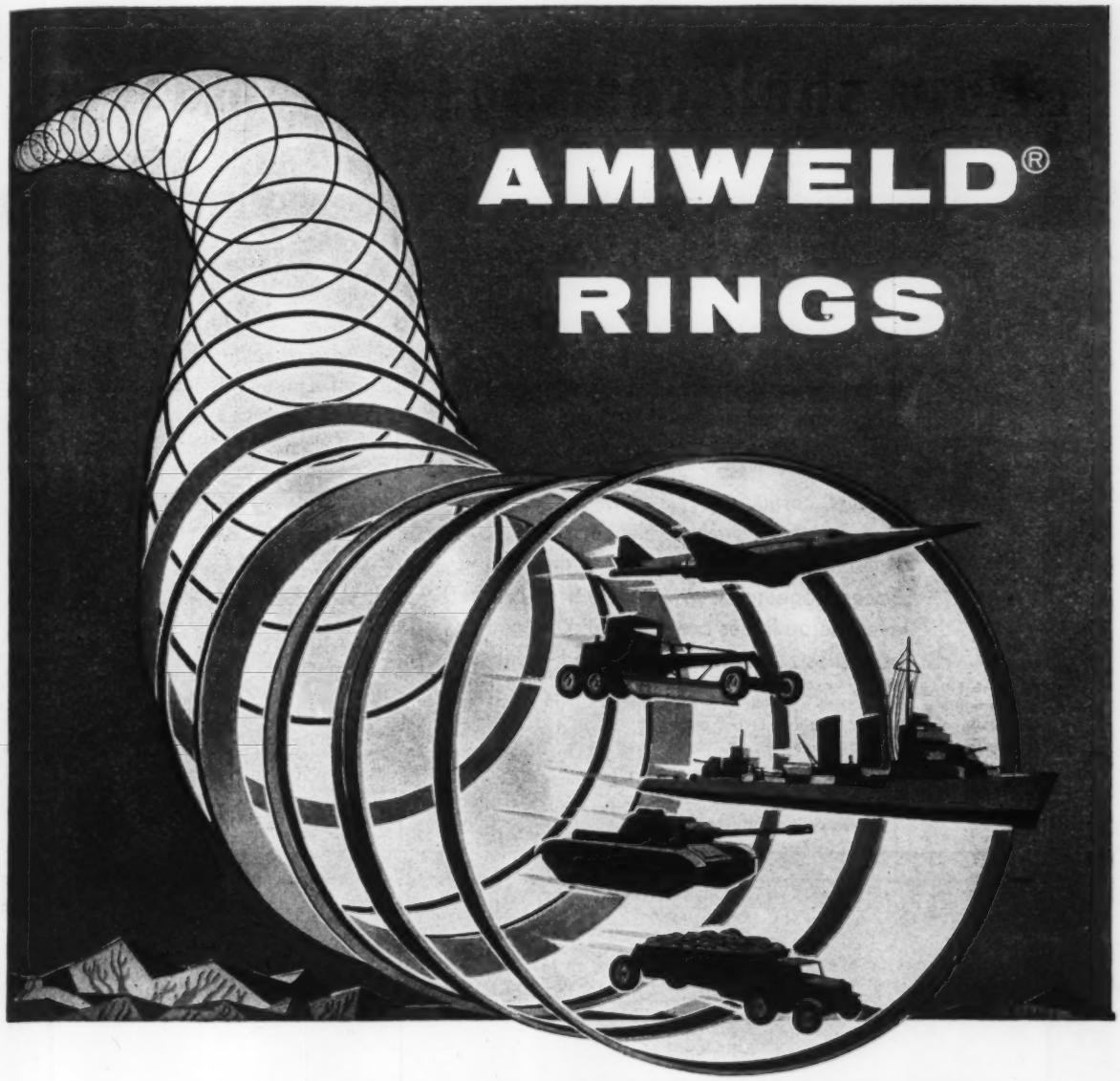

. . . part of America's industrial greatness

Send us your blueprint — we will be happy to help on any circular weldment problem you might have.

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The manufacture of circular weldments — rings, bands and components — has been an American Welding specialty since 1918.

Since its beginning, Amweld's skills and abilities have kept pace with America's production needs.

In 1949, Amweld was the first to successfully weld titanium alloy on a production basis.

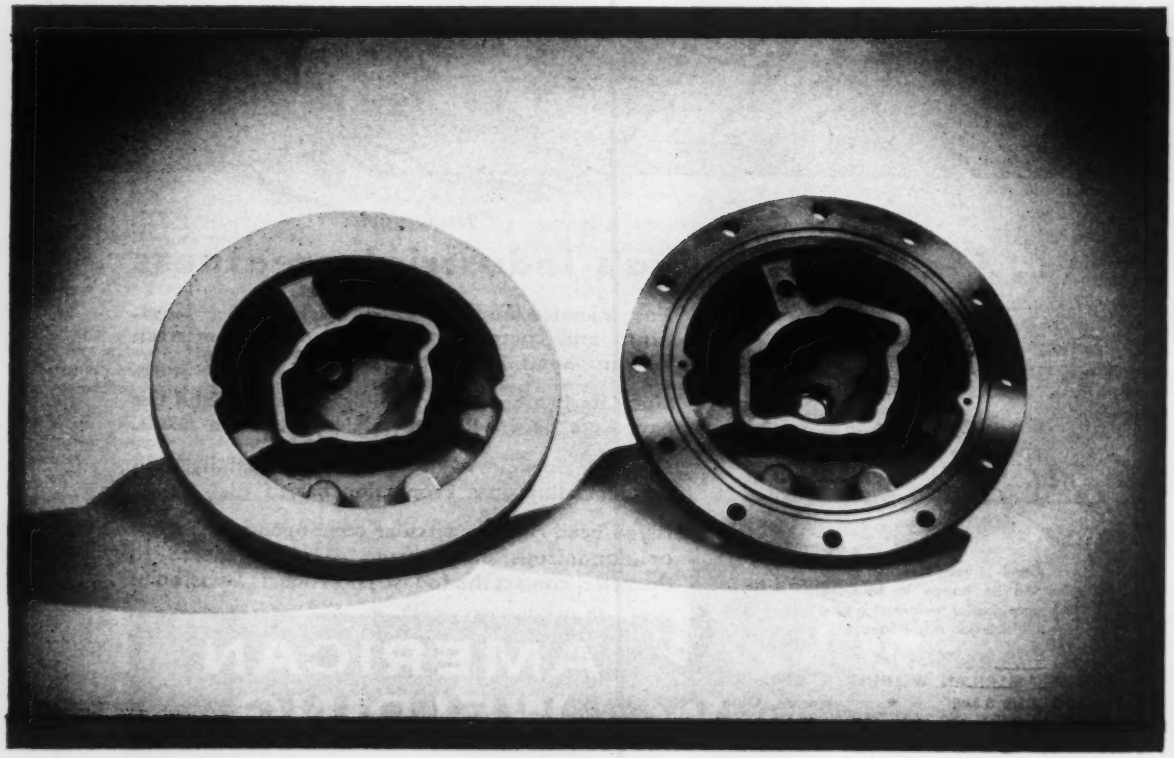
If you need rings or circular components of ferrous or non-ferrous metal, from 6 to 96 inches in diameter, contact the Industrial Products Division of

AMERICAN WELDING

How shell castings + ArmaSteel

This compressor head casting for an air conditioning unit produced by Central Foundry Division is a good example of the improvements and savings so often realized when ArmaSteel and shell castings are combined. This part is subjected to high chamber pressures and must be free of vapor leaks. ArmaSteel has the ideal physical properties for this job including good machinability.

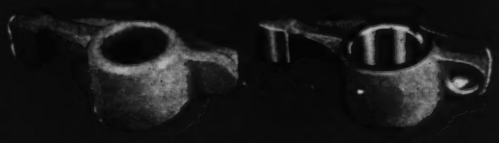
The shell casting process supplies clean, sand-free casting surfaces and greater dimensional uniformity which eliminates costly machining in the chamber, on the O.D. and profile milling on the contour. Thus, by using the shell casting process together with ArmaSteel in this part, material is saved, machining is saved, scrap losses are reduced 80%, and .... due to ArmaSteel's high physical properties . . . a greatly improved product results.



= savings for you

Here are two more parts improved by shell casting. The Crankshaft Sprocket was formerly machined from bar stock on automatic screw machines. By the use of shell castings on automatic chucking machines, material and machining were saved and a product with greater performance resulted.

Rocker Arms are a typical example where the uniformity of shell castings has made the part more adaptable to automatic machining. Preliminary grinding on pad ends has been eliminated, leaving only a finish grind. Center hole is cast with a minimum of finish stock eliminating a preliminary drilling operation.



In **SHELL CASTING** the mold is formed by a thin shell of sand bonded by a thermo-setting plastic. This shell has a hard, smooth surface as accurate as the pattern itself. Shell casting has many advantages:

- **Greater uniformity**
- **Closer tolerances . . . reduced finish allowances**
- **Greater accuracy which makes intricate designs possible**
- **Improved casting surfaces**
- **Freedom from residual sand**
- **Less excess metal resulting in lower freight charges**
- **Longer tool life**

ARMASTEEL is an arrested malleable iron of pearlitic structure. The size and arrangement of carbon nodules in this pearlite result in a freely machining material that has the strength and performance characteristics usually associated with carbon steel forgings. Thus ArmaSteel offers you:

- **Uniform structure**
- **Good machinability**
- **Excellent bearing properties**
- **Good wear resistance under heavy loads at high speeds**
- **Long fatigue life, high yield strength, maximum rigidity**
- **Good damping capacity**
- **Adaptability to selective hardening**

For further information about shell or sand castings, ArmaSteel, malleable iron or grey iron castings, write for descriptive literature . . . or request personal help from our experienced engineers, without obligation.

CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

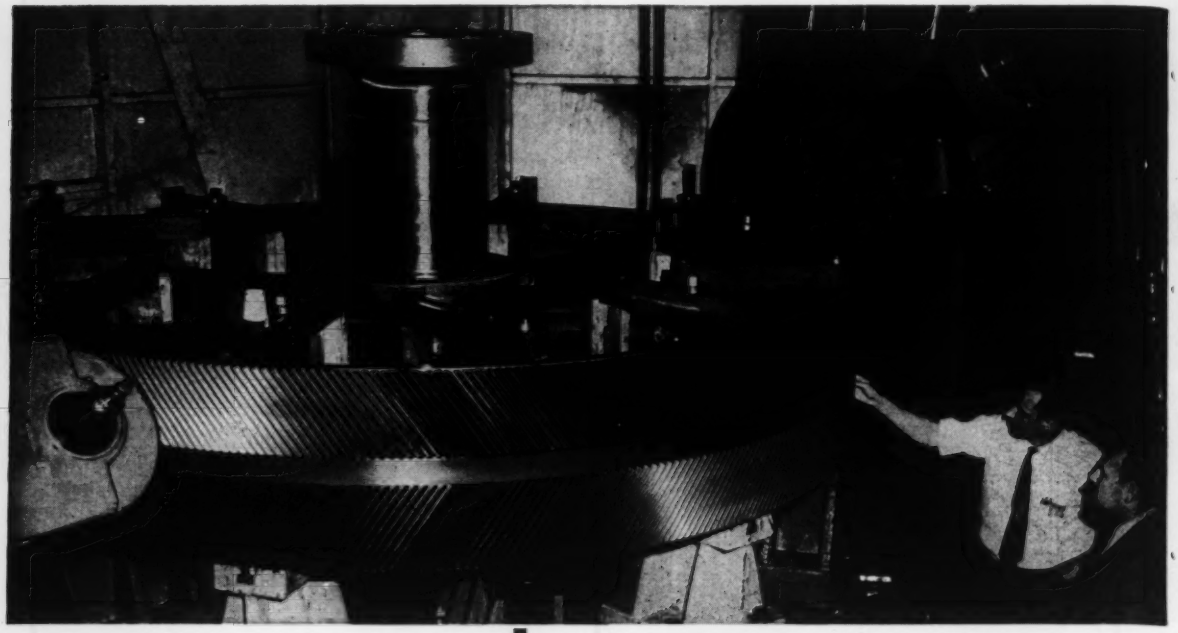
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION

SAGINAW, MICHIGAN • DEPT. 14

Circle 531 on page 19

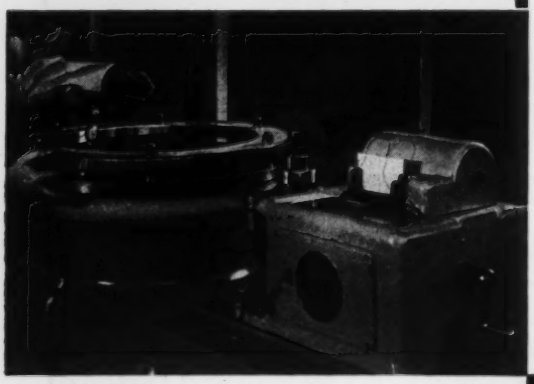
XUM



Precision high speed herringbone gear, 119" diameter, 4 pitch, A.G.M.A. Class 4, Rockwell hardness C33, concentricity tolerance .0006 between pitch diameter and journals. Maximum error of lead .0005 in entire face width of gear. Helix angle 37° 57 mins., 18" face width, 477 teeth.

are your gear tolerances "impossible"?

... then call WESTERN GEAR



"Red liner" machine, redesigned especially by Western Gear to insure utmost accuracy, in use to check accuracy of 26" fine pitch instrument gear.

When large external precision gears more than 42" in diameter are called for, they are cut on a 120" precision hobbing machine as shown at top, equipped with two index systems, one for roughing, the other for finishing to preserve the accuracy of the machine.

For large precision external gearing under 40" in diameter, a special 72" hobbing machine is used, equipped with index system limiting the machine to cutting large numbers of teeth only. Machines use Class AA hobs on specially made hob arbors and spindles.

Large precision internal gears are cut in a shaper of 72" capacity especially rebuilt to hold accuracy. All large precision gears in this category are shaved in special shaving machines having a capacity of 60". Careful temperature control is constantly maintained and rigid inspection is a by-word.

The manufacture of gears to total composite errors of .0005 and tooth-to-tooth errors of .0002 is an everyday occurrence at Western Gear! Technical know-how and unexcelled manufacturing facilities enable Western Gear to produce high quality gears to "impossible" tolerances in production line quantities. If precision quality gears are your problem, call on Western Gear skill and experience. We do the job when others fail!

"The difference is reliability" • Since 1888

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PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), SEATTLE AND HOUSTON • REPRESENTATIVES IN PRINCIPAL CITIES

WESTERN GEAR Corporation

ENGINEERS AND MANUFACTURERS

How gasket width affects the unit load required to maintain constant compression

An increase or decrease in gasket width does not always indicate that a change in the unit load is required to maintain constant compression. The type of gasket material used is the determining factor in most cases, as the examples below illustrate.

rubber gaskets

Since rubber is noncompressible, its load compression curve varies with the ratio of load area to free area. An increase in gasket width acts to impede sideflow, because it introduces additional material that must be displaced. To offset the added resistance, unit load must be raised to maintain constant compression. (It follows, of course, that the unit load must be reduced if the gasket width is decreased.) As shown in Figure 1, doubling the width of Armstrong DO-176—a straight rubber material—steps up the required unit load from 1400 psi for a ½-inch gasket to 2200 psi for a 1-inch gasket.

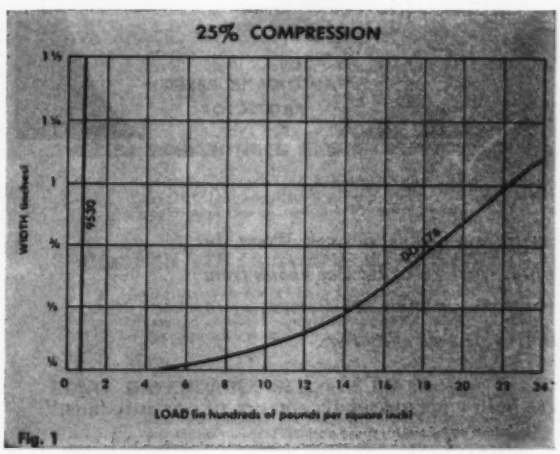


Fig. 1

cork composition

Cork composition, on the other hand, is truly compressible. There is no problem of resistance to sideflow—because there is no sideflow. As shown in the curve for Armstrong 9530 Cork Composition (Figure 1), a unit load of 75 psi produces 25 percent compression regardless of gasket width.

cork-and-rubber

The properties of cork-and-rubber can be modified by combining the two materials in varying proportions. For example, Armstrong DC-167 Cork-and-Rubber material has a high cork content. Its behavior, therefore, approaches that of Armstrong 9530 Cork Composition. To maintain constant compression with DC-167, unit load increases only from 110 psi to 120 psi when gasket width is increased from ½ inch to 1 inch (Figure 2).

With Armstrong DC-113 Cork-and-Rubber, gasket behavior will be more rubber-like because of the material's relatively low cork content. Figure 2 shows that 660 psi are needed to produce 25 percent compression on a ½-inch gasket. When width is increased to 1 inch, a load of 780 psi is required. Other Armstrong cork-and-rubber compositions provide intermediate degrees of compressibility to meet particular requirements.

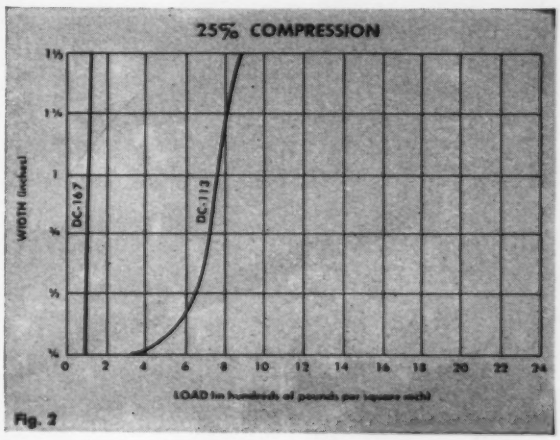
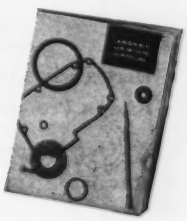


Fig. 2

The curves on this page illustrate why a compression specification should always state the sample gasket size, particularly with straight rubber compounds.

SEND FOR 24-PAGE GASKET MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy to Armstrong Cork Company, Industrial Division, 7109 Dean Street, Lancaster, Penna. For information on all Armstrong Gasket Materials, see Sweet's product design file.



Armstrong

GASKET MATERIALS

. . . used wherever performance counts

KLIXON

Motor Protectors help build Customer Acceptance of HUNTER attic fans

The Hunter Fan and Ventilating Company, a subsidiary of Robbins and Myers, Inc., has been making ventilating desk and ceiling fans since 1886. Hunter knows from experience the value of built-in Klixon Protectors in their fan motors . . . how Klixon Protectors help assure trouble-free operation.

Here's what Hunter has to say about the value of Klixon Protectors:

"Our factories have produced nearly 200,000 attic fans. This experience has taught us that dependability and trouble-free operation require the best in materials and components on our product. We are proud to state that all of our 115 volt, single phase attic fan motors are equipped with Klixon protectors. They extend the life of our product, reduce service problems and assure the dealer of profit and the home owner of convenience. These factors have built widespread acceptance of our attic fans."

You too can help motors work dependably in your products by specifying and using Klixon protected motors. They will reduce maintenance costs, service calls and repairs and replacements. The additional cost is low . . . the benefits exceptionally worthwhile.

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METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3209 FOREST STREET, ATTLEBORO, MASS.

Circle 534 on page 19

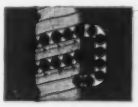
HOW MANY POSITIONING PROBLEMS CAN THESE AMAZING UNITS SOLVE FOR YOU?

Frankly, we don't know. Almost daily we hear of some new application that never occurred to us. But we do know this: electronics engineers are achieving the "impossible" with Saginaw ball/bearing Screws and Splines, particularly these miniature sizes, from 1½ to 3 inches long.

CHECK THESE UNPRECEDENTED PERFORMANCE ADVANTAGES:

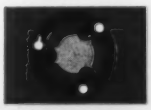
Saginaw ball/bearing SCREWS

Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

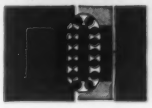


At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

Saginaw ball/bearing SPLINES



The *Saginaw b/b Spline* radically increases the efficiency of transmitting or restraining high torque loads. Instead of *sliding* against each other, the mating surfaces *glide* on rolling balls.



The steel balls recirculate in closed circuits formed by mating longitudinal raceways spaced around the circumference of both inner and outer splines. Guides return balls to starting point.

UP TO 5 TIMES MORE EFFICIENT

Up to 95% efficiency guaranteed in transforming rotary to linear motion; over 80% efficiency, linear to rotary. Require less than 1/5 as much torque as conventional Acme screws for equal output.

SAVE SPACE, WEIGHT, POWER

Permit much smaller, lighter motors and auxiliary equipment. Saginaw b/b Screws have been built from 1½ inches to 39½ feet in length.

PRECISE POSITIONING AND SYNCHRONIZING

Machine-ground types provide precision control within fractional thousandths of an inch, plus perfect synchronization of two or more movements.

OPERATE IN VERY ADVERSE ENVIRONMENTS

Saginaw b/b Screws have been designed and built to operate from −75° to +900° F. Even if lubrication fails or cannot be originally provided, they will still function with remarkable efficiency.

LONG, DEPENDABLE SERVICE LIFE

Accurately predictable life engineered to design requirements. Special Gothic arch groove design and multiple circuits assure dependable performance.

40 TIMES LOWER FRICTION COEFFICIENT THAN ORDINARY SLIDING SPLINES

By applying the same basic gliding ball principle pioneered by Saginaw in the ball/bearing screw, this revolutionary new kind of spline makes practical new engineering designs never before possible.

TRANSMIT OR RESTRAIN HIGH TORQUE LOADS FAR MORE EFFICIENTLY

In any application where column length must change under torque load, the Saginaw b/b Spline offers unprecedented freedom from sliding spline restrictions.

WIDE CHOICE OF ATTACHMENTS

Can be fitted with integral gears, clutch dogs, bearing and sprocket seats or other attachments for use with electric, hydraulic or pneumatic units.

WIDE RANGE OF SIZES AND TYPES

Saginaw b/b Splines have been designed from 3 inches to 9 feet in length, and from ⅜ to 3¾ inches in diameter. To convert push-pull to rotary motion, helical types are available with very high leads, ranging from 20:1 to 100:1.

Saginaw

ball bearing Screws & Splines

MAIL COUPON TODAY FOR NEW ENGINEERING DATA BOOK

Saginaw Steering Gear Division
Ball Bearing Screw & Spline Operation
General Motors Corporation
Dept. 4H, Saginaw, Michigan

Please send your Engineering Data Book to:

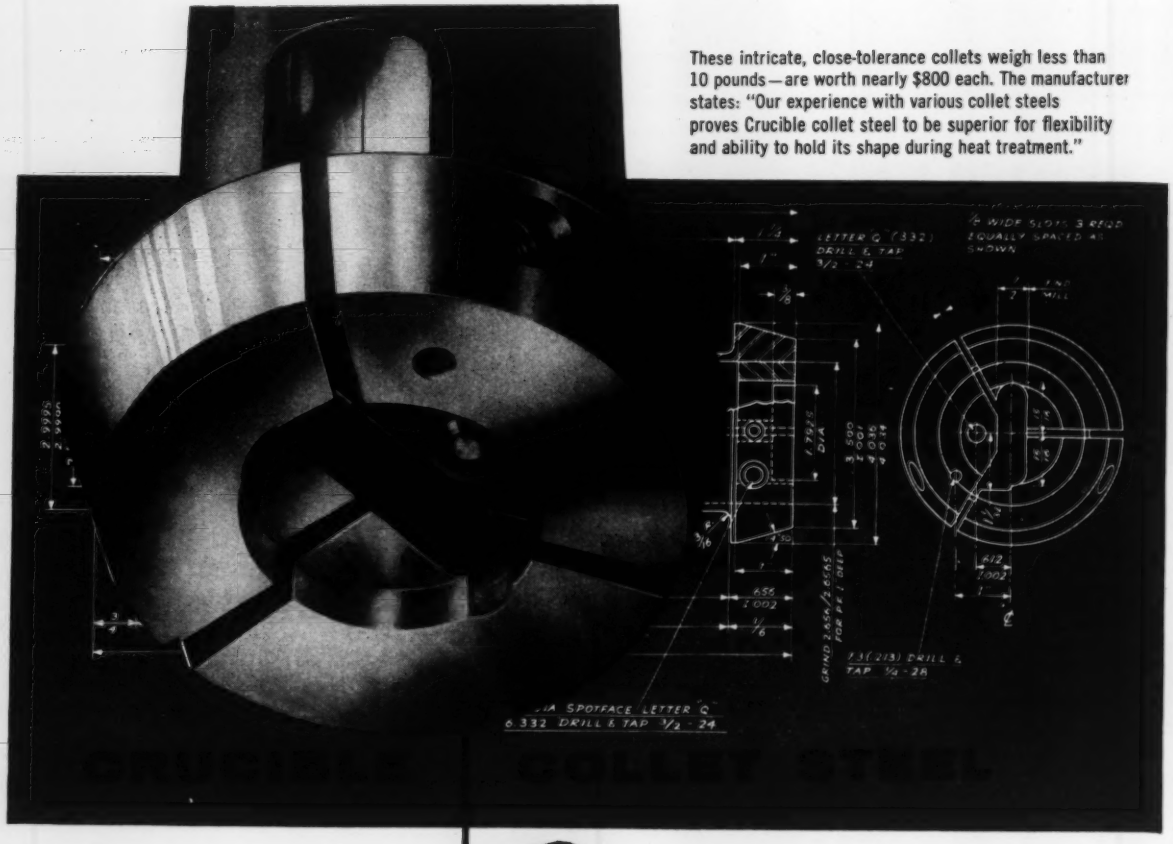
Name—Title_____

Firm_____

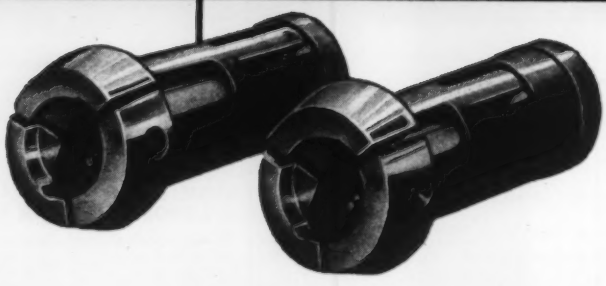
Address_____

City_____ Zone____ State_____

Circle 535 on page 19



These intricate, close-tolerance collets weigh less than 10 pounds—are worth nearly $800 each. The manufacturer states: "Our experience with various collet steels proves Crucible collet steel to be superior for flexibility and ability to hold its shape during heat treatment."



for minimum distortion after heat treatment

These collets are used in machining the anchoring end of jet engine turbine blades, while locating the part from reference points on the airfoil section of the blade. It's a job that demands a steel which will not distort during heat treatment. The collet head is heated to Rockwell 58-60 C—the body tempered to 35-38 C.

The steel used is a special Crucible non-warping alloy collet grade. The collet manufacturer, Balas Collet Mfg. Co., Cleveland, Ohio, reports: *The extreme accuracy built into these collets while they are still in the soft state shows less than .0005" distortion on any dimension after heat treatment.*

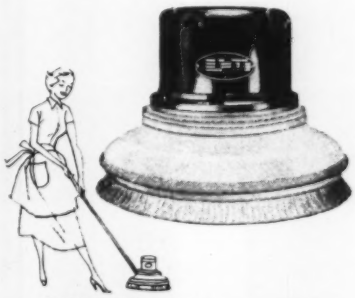
Crucible collet steel was developed specifically for spring collets—or *any* parts with rigid requirements of excellent machinability and high attainable hardness. Other properties—in almost limitless combination—can be had in other Crucible alloy grades. To see what information is available on these alloy steels—or *any* Crucible special steel—get your copy of the *Crucible Publication Catalog*. Write *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

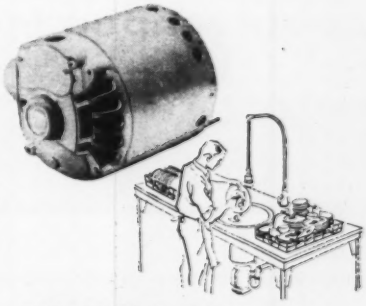
Circle 536 on page 19

Which of these *Customized* motor features will improve your product design?

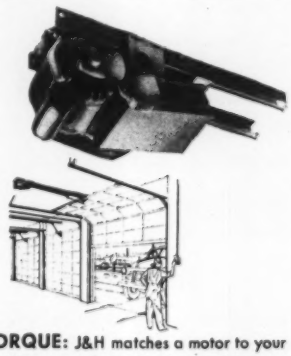


SILHOUETTE: J&H fits a motor to your dimensions. *Example:* A special low-silhouette motor enables a manufacturer to market a floor polisher that operates under furniture and fixtures.

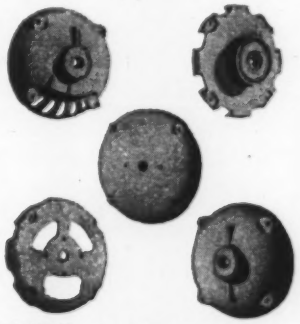
NOISE LEVEL: J&H builds motors with very low decibel levels. *Example:* Restaurant and store patrons are never annoyed by this super-quiet meat slicer using a special J&H motor.



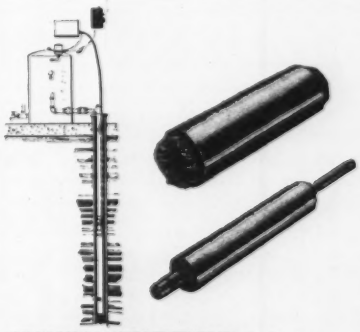
ENVIRONMENT: J&H can meet your most critical environment specs. *Example:* Commercial food disposers operate under high heat and humidity. Special J&H features keep motor running cool.



TORQUE: J&H matches a motor to your torque curve. *Example:* Automatic doors call for fast, dependable starts and stops, instant reversing. J&H-engineered windings guarantee performance.



STYLING: J&H blends a motor into your design with special contours and finishes. *Example:* These typical J&H end bells can be used to improve a product's appearance, enhance sales appeal.



UNUSUAL CONDITIONS: J&H designs motors or components to new, unusual conditions. *Example:* Deep-well submersible pump motor gives trouble-free service hundreds of feet underground.

Design your product to do a job . . . not to fit a motor

Eliminate the size, shape and performance limitations of standard motors. Take a tip from these typical manufacturers who are designing more efficient and attractive, easier-to-sell products by using J&H *Customized* motors. Check your specific application needs with our motor engineers. Write Jack & Heintz, Inc., 17626 Broadway, Cleveland 1, Ohio.

SEND FOR FREE BOOK

"When to Specify Special Motors" . . . a valuable 20-page design guide. Includes charts, tables, drawings, specifications, case histories . . . all factors to answer your most searching questions. Write to Jack & Heintz today!

Circle 537 on page 19

JACK & HEINTZ ***CUSTOMIZED*** ELECTRIC MOTORS

AMPCO — ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

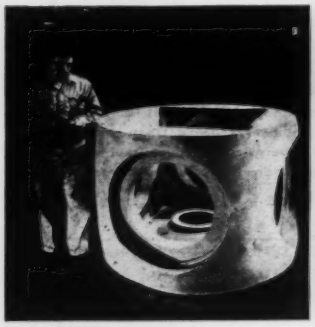
What's so *different* about Ampco Metal?

It's made to last — and does!

Not by chance, either! Ampco's pioneering experience in the development and production of special copper-base alloys has resulted in strict manufacturing precautions. These and the narrow metallurgical limits, the continual controls, the best in equipment and experienced personnel are all part of the Ampco secret. Yes, they're the big reasons why Ampco alloys enjoy world-wide acceptance — why so many manufacturers insist on the year-to-year uniformity and reliability that results from Ampco's "know-how" and controlled alloy-making procedures.

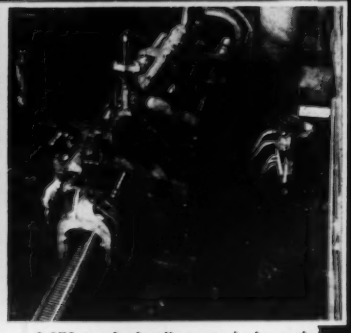
And because Ampco is made to last — and does — it performs its greatest service in those applications where severe load, wear, or corrosion problems must be solved.

Here's another thing that's different about Ampco Metal: It is produced by centrifugal-, sand-, or precision-casting, shell-molding, extrusion, and forging processes — on a production basis. It's also available as sheet or plate. Your Ampco field engineer can make unbiased recommendations, because Ampco offers this complete one-source service. Call him in. Also write for Bulletin 33.



Sand castings in any size up to 14,000 pounds — and centrifugal castings up to five tons — are produced in Ampco foundries.

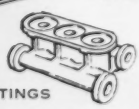
Ampco's one-source service includes production-run machining of copper-base alloys to the quality standards of the aircraft industry.



2,275-ton hydraulic press in Ampco's modern, laboratory-controlled mill for extruding rods, bars, hollow rounds, and shapes.

AMPCO METAL, INC. Dept. MD-9, Milwaukee 46, Wisconsin • West Coast Plant: Burbank, California

AMPCO® **THE METAL WITHOUT AN EQUAL**



SAND CASTINGS

CENTRIFUGAL CASTINGS

FABRICATION

CAST-TO-SIZE CASTINGS

FORGINGS

SHELL-MOLDED CASTINGS

EXTRUSIONS

SHEET AND PLATE

MACHINED PARTS

D-54

THE NEW HOWARD FRACTIONAL H.P. MOTOR SELECTOR CHART

WILL ANSWER YOUR QUESTIONS ON SMALL MOTORS

YOURS
FREE
ON REQUEST

Characteristics and performance ranges of all fractional h.p. motor types are charted in detail in this new binder sized Fractional H.P. Motor Selector Chart now available to Engineers and Purchasing Agents. Speed-torque curves for basic motor types are illustrated as well as other valuable motor data. Compiled by the Howard engineering department, the Howard Motor Selector is yours for the asking. Just fill in the coupon below for your free copy by return mail.

Howard motors: INDUCTION TYPES 1/1000 to ¼ h.p. • UNIVERSAL & D.C. TYPES 1/200 to ½ h.p. • SHADED POLE TYPES 1/2000 to ⅓ h.p. • GEAR MOTORS, BLOWERS, SERVO MOTORS

HOWARD INDUSTRIES, INC. • RACINE, WIS.

SALES OFFICES: 208 S. La Salle St., Chicago 4
942 S. LaBrea Ave., Los Angeles 36 • Room 4822 Empire State Bldg., New York 1

DIVISIONS: EHC ELECTRIC MOTOR CORP CC CYCLOHM MOTOR CORP RACINE ELECTRIC PRODUCTS

Buy Defense Bonds

DEPT. MD-9 HOWARD INDUSTRIES, INC., RACINE, WIS.
Please send me your free Howard Motor Selector Chart by return mail.

NAME.....TITLE.....
COMPANY.....
ADDRESS.....
CITY.....STATE.....
FILL IN FOR FURTHER DETAILS.
Please have a Howard Sales Engineer call with full details on Howard Motors ☐

Circle 539 on page 19

NEW "Unionmelt" Welding Assemblies

for greater job versatility- performance dependability

Versatility and dependability are yours at an all time high in an improved new line of UNIONMELT welding assemblies . . . These units embody the greatest variety of machine combinations, job applications, and design features ever offered for submerged arc welding.

Wire feed units are simply constructed and are highly efficient . . . Identical mounting dimensions for heads, brackets, and slides allow for any number of desired assembly combinations.

Welding heads have exceptional flexibility because of sturdy new mounting fixtures which provide for vertical, horizontal, and rotary adjustment. Stationary and self-propelled combinations are also available.

The wide variety of standard and custom UNIONMELT welding assemblies can easily be made to fit your particular applications—at costs lower than many current standard models.

See your local LINDE *representative today for information on the many other new features—or write for free illustrated literature.*

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

Linde Trade-Mark

The terms "Linde" and "Unionmelt" are registered trade-marks of Union Carbide and Carbon Corporation.

Where on earth will you find such machinery...

Battery of four No. 4A Warner & Swasey turret lathes for accurate machining of heavy gear blanks to 28" diameter.

...at Illinois Gear, of course.

Pictured here is a battery of large precision turret lathes for machining heavy gear blanks *up to 28" in diameter!*

These machines are typical of all the precision equipment that makes *Illinois Gear* the most modern, best equipped and the largest gear manufacturer in the world . . . equipment that offers a new concept in the manufacture of finest quality gears.

Combine this with the skilled craftsmen who *know how* to operate this equipment and you have the reason why *Illinois Gear* can produce gears that measure up to your most demanding specifications . . . why *Illinois Gear* can make and fulfill delivery promises.

ILLINOIS GEAR
CHICAGO

Look for this mark IGG® *the symbol on finer gears*

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

Circle 541 on page 19

How FLEXLOC clinch nuts save production time

If you are building assemblies of thin-section materials, you can make secure bolted connections with FLEXLOC clinch nuts. Use them instead of cage nuts, anchor nuts and weld nuts. They are easy to install—no riveting or welding is required.

When you design with 1-piece, all-metal FLEXLOC clinch nuts, you simplify production operations by eliminating complicated nut-and-lockwasher assemblies. And the nuts cannot fall off or get lost during maintenance operations.

When you thread in a screw, the FLEXLOC locks it wherever wrenching stops (as soon as 1½ screw threads or more project through the locking section). Locking action is positive and dependable. No matter how many times your product must be reassembled during maintenance or repair, the FLEXLOC holds securely every time. Its locking life is virtually unlimited. It cannot be loosened by vibration.

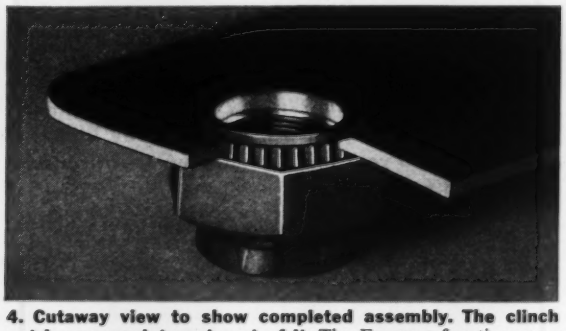
Standard FLEXLOC self-locking clinch nuts come in sizes #4 through ¼ in., for use in materials from 1/32 to 3/16 in. thick. They are made in alloy steel, stainless steel, brass and aluminum. FLEXLOC clinch nuts and clinching tools are available through your authorized industrial distributor. Call him today. Write us for complete specifications, or for information about your special locknut problem. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

It's easy to install a FLEXLOC clinch nut

1. Hole in your subassembly accommodates the knurled shank of the FLEXLOC. The holding fixture is fitted with an inexpensive FLEXLOC dolly tip.

2. Fit the knurled shank of the nut into the hole. Your production engineers can easily design fixtures to make this operation completely automatic.

3. Clinch the shank to the subassembly with a single stroke. This electric press is equipped with a FLEXLOC punch tip which also can be used with an ordinary hammer.



4. Cutaway view to show completed assembly. The clinch nut is now an integral part of it. The FLEXLOC functions as a tapped hole—one that will lock a screw securely in place.

FLEXLOC locknuts are sold through authorized industrial distributors

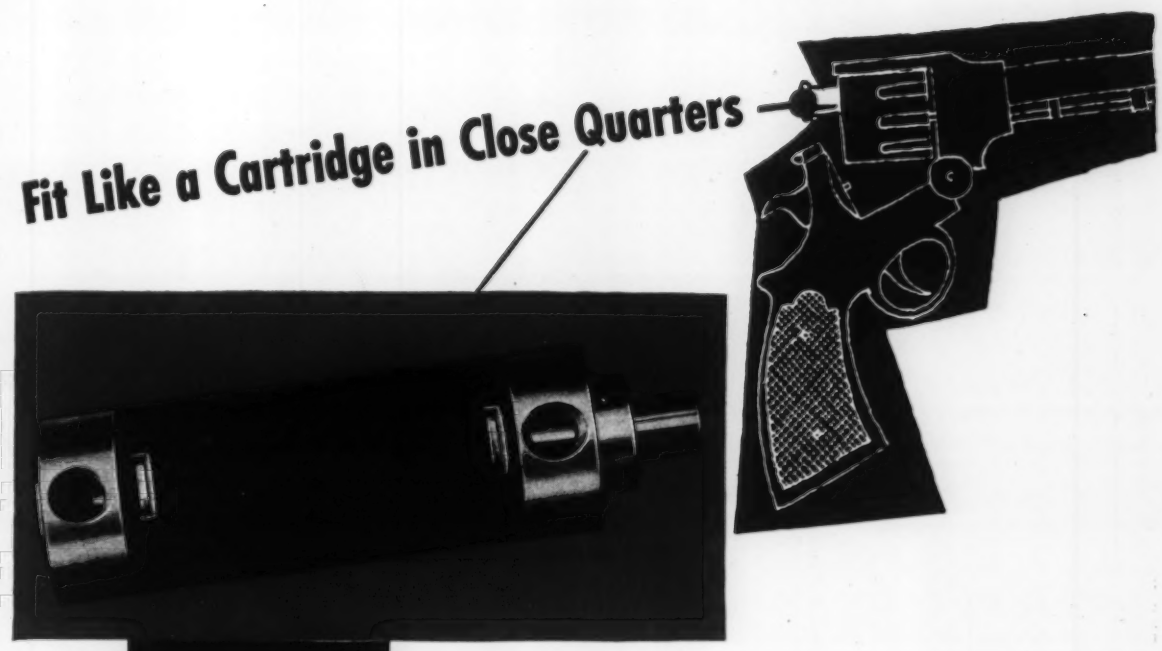
STANDARD PRESSED STEEL CO.

FLEXLOC LOCKNUT DIVISION **SPS**

JENKINTOWN PENNSYLVANIA

Circle 542 on page 19

Fit Like a Cartridge in Close Quarters



O-M

CYLINDERS TIE-RODLESS

(150 PSI AIR—UP TO 1500 PSI OIL)

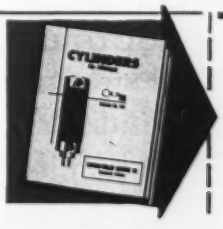
These compact, streamlined cylinders, that require ⅓ less installation space than the conventional type, slip easily into the hard-to-reach places, because the O-M Special Interlocking Mechanism eliminates both tie-rods and projecting end caps. Besides, the precision honed, seamless steel cylinder body can be turned down to fit in unusually tight spots.

Other important features that reduce maintenance costs and step up efficiency include:

- ***Two point Bearing,*** one on piston and one in rod gland provide better balance and protect against drag on rod—giving O-M the lowest co-efficient of friction at low or high speeds;
- ***End Covers*** (head) machined steel;
- ***Leather Back-ups*** on Hydraulic cylinders prevent extrusion on end plugs—O-ring seals;
- ***Piston Packings***—self-adjusting U-cup, Vee, or ring type;
- ***Rod Packings***—self-adjusting U-cups for air, Vee-type for oil;
- ***Rod Scraper***—cleans piston and protects rod, packing and bearing;
- ***Mounts***—interchangeable, ductile iron or steel—easily installed without disassembling the cylinder;
- ***Ports*** can be oriented to facilitate piping;
- ***All Cylinders*** tested at operating pressures before shipment;
- ***Cylinder*** easily disassembled, inspected, serviced, and re-assembled.

Available in a full range of sizes (1½" to 8" bores) with standard, 2 to 1, or oversize rods with male or female rod end, and length of stroke to meet your requirements. Completely interchangeable parts.

Write TODAY for FREE catalog showing cylinders and complete line of mounting brackets.



ORTMAN-MILLER MACHINE COMPANY
7 143rd Street, Hammond, Indiana

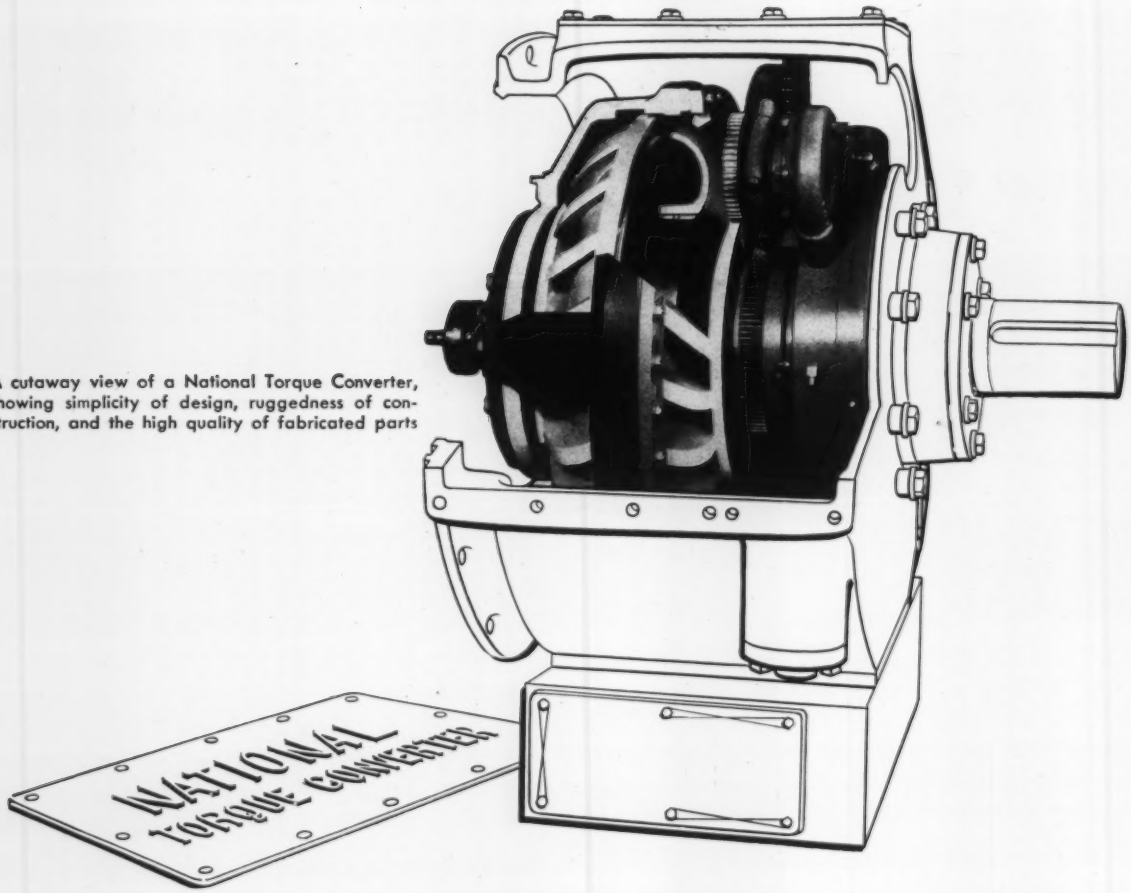
☐ Have representative call ☐ Send Bulletin 103

Name_____ Position_____

Company_____

Address_____

City_____ Zone____ State_____



A cutaway view of a National Torque Converter, showing simplicity of design, ruggedness of construction, and the high quality of fabricated parts

It's rugged...it's durable...it's dependable...

it's a NATIONAL Torque Converter

The simple, rugged design of National Torque Converters offers many unique features.

Converter is easy to install.

Equipment service life is prolonged.

Maintenance of equipment and torque converter is at a minimum, even in the roughest, toughest industrial service.

Meets the most rugged demands of practically every heavy-duty application—oil drilling rigs, excavating, earth-handling, mining, logging and similar equipment.

In addition, precision fabrication provides uniform high efficiency permitting standardization of National Torque Converter on your equipment with assurance of uniform top performance.

And you have a choice of 6 basic hydraulic circuit sizes, each with a range of input ratings, to permit *exact matching* of torque converter to engines of 100 to 1000 horsepower.

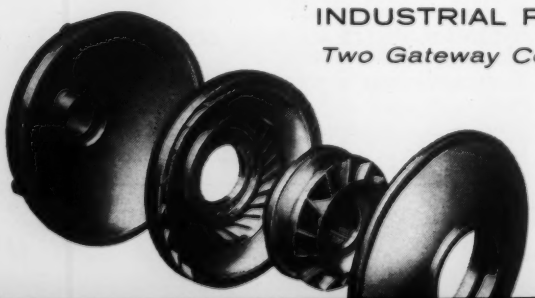
National engineers will gladly work with your designers to arrive at the correct size and capacity of National Torque Converter for the specific power-speed characteristics of your equipment. Why not call on us today?

A copy of Bulletin No. 468, descriptive of National Torque Converters, is available on request.

THE NATIONAL SUPPLY COMPANY

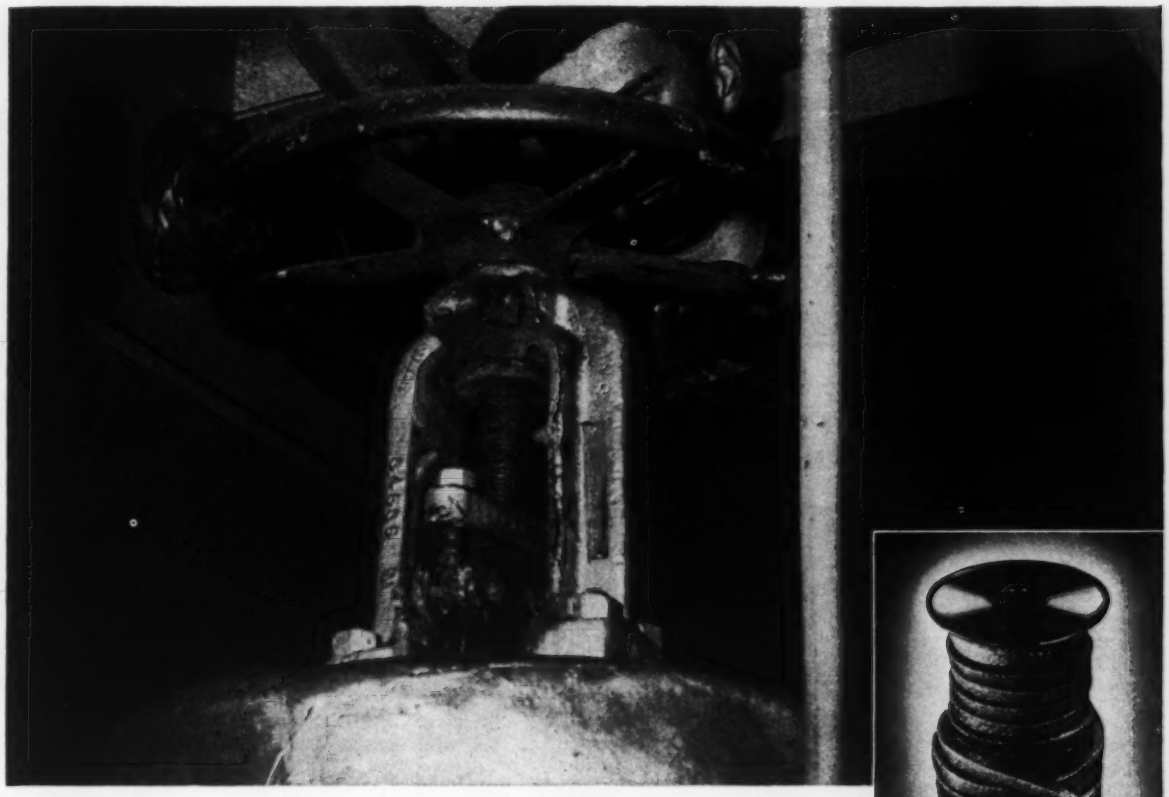
INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.



Pace-setters in the progress of industrial power transmission

Circle 544 on page 19



NEW R/M VALVE STEM PACKINGS

for temperatures to 1000°F . . . and higher

If you are designing valves or expansion joints for high temperatures, you can be sure of maximum performance when you specify these new R/M Packings. They feature great resistance to corrosion and excellent dimensional stability, and are tops for handling superheated steam, hot gases and oils.

Built to take it

These new R/M Packings are made by braiding AAA grade, wire-inserted asbestos yarns over an asbestos plastic core. All organic materials that tend to carbonize at high temperatures have been practically eliminated by a special manufacturing process. Thus the packing core remains granular in structure throughout service life and shrinkage is reduced to an absolute minimum. This means that fewer adjustments are required and resistance to hardening is increased.

Protected against corrosion

A sacrificial metal inhibitor is compounded into the packings to check corrosion when valves are stored after hydrostatic tests. The packings also contain special corrosion resistors which protect them at service temperatures.

Types and sizes

For temperatures up to 1000°F, types made with Monel-inserted yarns are recommended; available with surface graphite (No. 350) or with additional metal inhibitor lubricant on the outer jacket (No. 351). Above 1000°F, packings made with Inconel-inserted yarns are recommended. The graphite-coated type is No. 325; metal-lubricant type is No. 326. Standard sizes: ⅛ in. to ½ in. in $\frac{1}{16}$ in. increments; ½ in. to ¾ in. in ⅛ in. increments.

One of the pioneers in the packing industry, R/M offers complete cooperation in the development of packings to fit your individual requirements.

For complete information, send for bulletin on High Temperature Valve Stem Packings

R/M PACKINGS
RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N. J.
MECHANICAL PACKINGS AND GASKET MATERIALS

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Packings • Asbestos Textiles • Industrial Rubber, Engineered Plastic, and Sintered Metal Products • Abrasive and Diamond Wheels • Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Bowling Balls

Circle 545 on page 19

CALL ON R/M ENGINEERING SERVICE

This Snow Train travels across frozen Arctic wastes on 1200-mile treks, carrying from 130 to 175 tons of supplies to radar outpost crews. To overcome low-temperature problems, the brake linings are bonded with one of the new R/M adhesives.

By using Ray-BOND adhesives to bond the metal name plate to the plastic case, an electric razor maker reduced personnel for this operation 75%—because of rapid adhesion and elimination of the pressing operation.

R/M ANNOUNCES A SPECIALIZED LINE OF ADHESIVES, PROTECTIVE COATINGS AND SEALERS

R/M's specialized new Ray-BOND Adhesives, Protective Coatings and Sealers can now cut costs and simplify bonding for a wide range of materials and applications.

Ray-BOND thermosetting adhesives offer excellent bonding qualities and heat stability. Compounds are based on synthetic or natural rubber, resin bases of all types, and combinations of rubber and resins which provide good performance under the most severe operating conditions. Ability to resist temperature extremes ranging from −80° to as high as 700°F makes these adhesives very desirable for high-temperature applications.

If bonding, laminating, sealing or coating can cut costs or improve production in your own operations, contact Raybestos-Manhattan now. From over 20 years' pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings, R/M has acquired a wealth of knowledge and experience that could help solve problems you may be facing now. Our engineers are ready to work closely with yours—to make that solution prompt, practical and profitable for you.

Write now for your free copy of R/M Bulletin No. 650. It contains the engineering information you'll want on Ray-BOND Adhesives, Protective Coatings and Sealers.

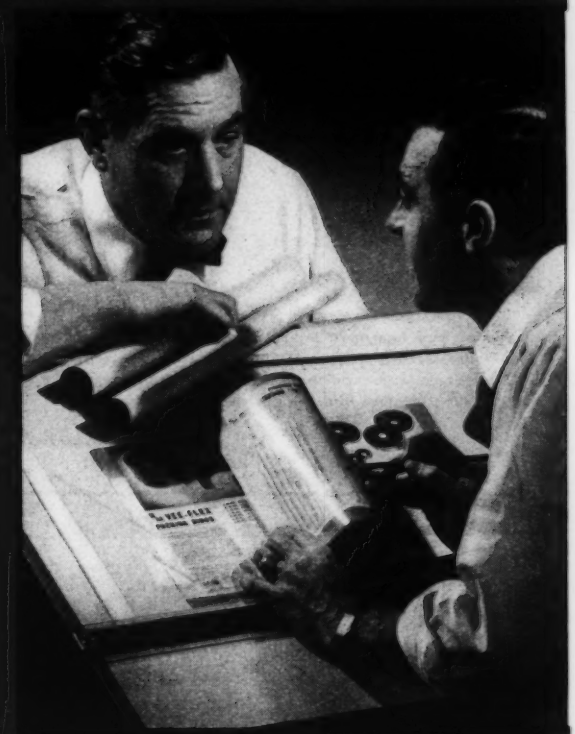
EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METALS, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings | Fan Belts and Radiator Hose | Mechanical Packings and Gaskets | Abrasive and Diamond Wheels | Industrial Drive Belts | Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS



MOLDED PARTS—Rubber • Silicone

R/M designs the *correct* molded part for your new product, or to improve an existing one—in natural or synthetic rubber, or silicone to resist chemicals, oils, abrasion, heat, other conditions. High standards of precision and exacting quality controls assure long, trouble-free service under all conditions of use. R/M engineers are specialists in the application of molded parts or components . . . and will assist you in determining the best design and material for your requirements. R/M craftsmanship is backed by over 60 years' experience in the manufacture of the molded and industrial rubber products you need . . . as well as custom-produced cut and extruded parts. Let R/M work with you on your next design.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000

PACKINGS, GASKETS ASBESTOS TEXTILES and "TEFLON"* PRODUCTS

Here are two of R/M's superior hydraulic and pneumatic packings: *R/M Vee-Flex Packing Rings* to fit every piston and rod, giving the right interference for automatic sealing even above 6000 psi. Outstanding features: polymer-saturated fabric, precision trimming, and rock-hard adapters to prevent extrusion. *R/M Fabric Piston Cups*—accurate molding assures dimensional uniformity and efficient sealing; thorough penetration of compound into fabric protects cups from wicking action and increases resistance to ply delamination.

R/M offers complete cooperation in the development of a packing to fit your individual needs

**Du Pont Trademark*

For booklet shown, or other data, write, phone or wire

PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J. • GRegory 3-2000

ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa. • Manheim 5-2211

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

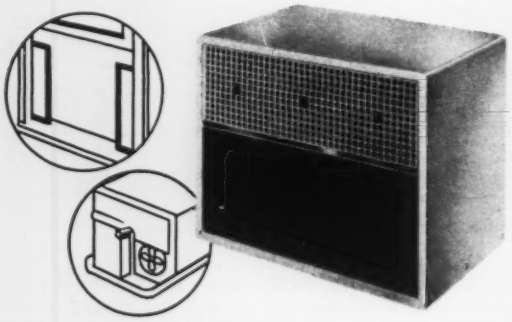
Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

PICKER X-RAY equipment showing Rubatex as soft resilient cushioning pad to support patient in comfort during x-ray examinations. Highly radiolucent, Rubatex makes no perceptible difference in the radiograph. Will not soak up barium salt solutions or other fluids—wipes clean with damp cloth and needs no cover.



The Rubatex Closed Cellular Rubber gaskets applied in 1956 G.E. THIN LINE ROOM AIR CONDITIONERS are designed to effectively seal out moisture, dirt and drafts. Shown in cutaway drawing are two Rubatex seal gaskets on the window closure panel and one behind the control plate of the unit.

Rubatex pad oscillates on base of PORTABLE ELECTRIC TOOL's industrial sanding unit. Reduces vibration to minimum. Resists deterioration from solvents used in industrial sanding jobs.

doing unusual jobs unusually well for 20 years

Rubatex's 20-year record meets the demand of industry . . . cost-wise and performance-wise . . . in doing thousands of unusual gasketing, sealing, cushioning, packaging, sound deadening and vibration isolation jobs better and cheaper than ordinary soft rubber materials.

From hearing-aid "cushioning" to packing for scientific instruments to radio and electronic dust-proof seals to special aircraft, automotive and electrical appliance sealing applications . . . here's tested proof of a versatile material worth your investigation. Offers advantages no other soft rubber materials can. Why not give Rubatex a test? Write us today.

G.A.I. RUBATEX

PIONEER MANUFACTURER OF CLOSED CELLULAR RUBBER

also manufacturers of:
Rubatex Closed Cellular Vinyl
Rubatex Insulation Hardboard
Rubatex-Crepe
Rubatex Softee-Crepe
Rubatex Vinyl Foam
Rubatex Plastic Seine Floats

GREAT AMERICAN INDUSTRIES, INC.
RUBATEX DIVISION, Bedford, Virginia

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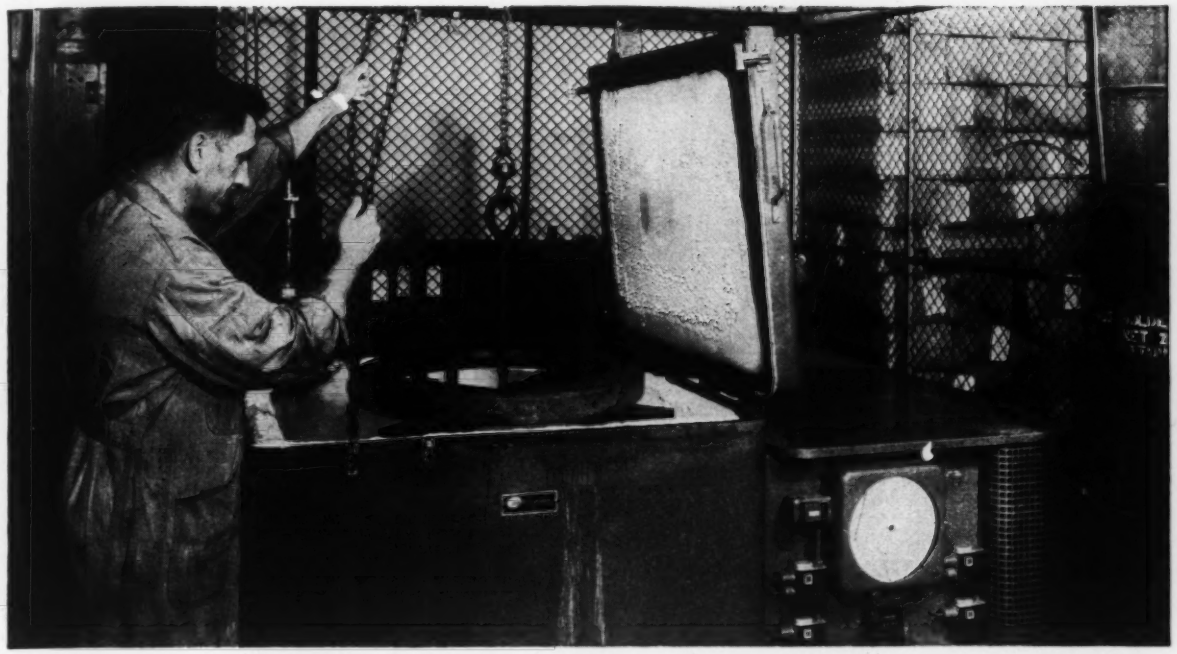
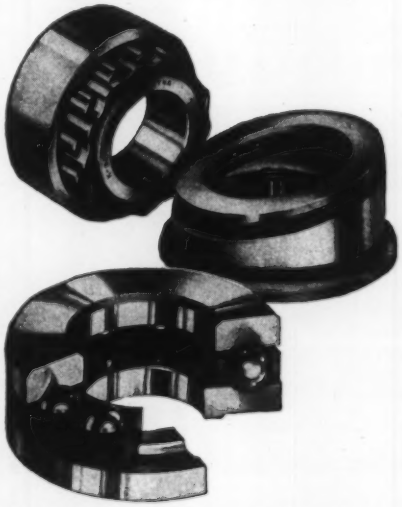


AETNA FREEZES BEARINGS AT 130° BELOW ZERO

to give you better, more dependable anti-friction performance



Typical examples of Special Aetna Super-Precision Bearings . . . manufactured to the most advanced dimensional control standards including stabilization.

Looks warm and comfortable, doesn't he?—the operator pictured here. Actually he's only inches away from one of industry's coldest work spots—the "deep freeze" vault where Aetna bearing components are treated at temperatures as low as 130 degrees below zero.

This special sub-sub zero treatment makes certain that vital Aetna bearings built into high precision products will provide the dimensional stability so necessary for sustained peak efficiency and longest life expectancy. In this quick-aging process the steel's metallurgical structure undergoes transformation—from the relatively soft austenite retained from heat treating into the much harder, tougher, fatigue resisting property, martensite. The result is a stabilized bearing that permanently holds it precise tolerances and assures the lowest possible coefficient of friction no matter how severe or varied the operating temperatures may be.

We call this the "cold war" against friction—one of the many advanced ways and reasons Aetna consistently produces anti-friction products that lead the field in dependability and cost-cutting efficiency.

Perhaps stabilization can solve a stubborn bearing application problem for you, too. Aetna's technical staff is ready to help you investigate. Why not outline your problem for their study?

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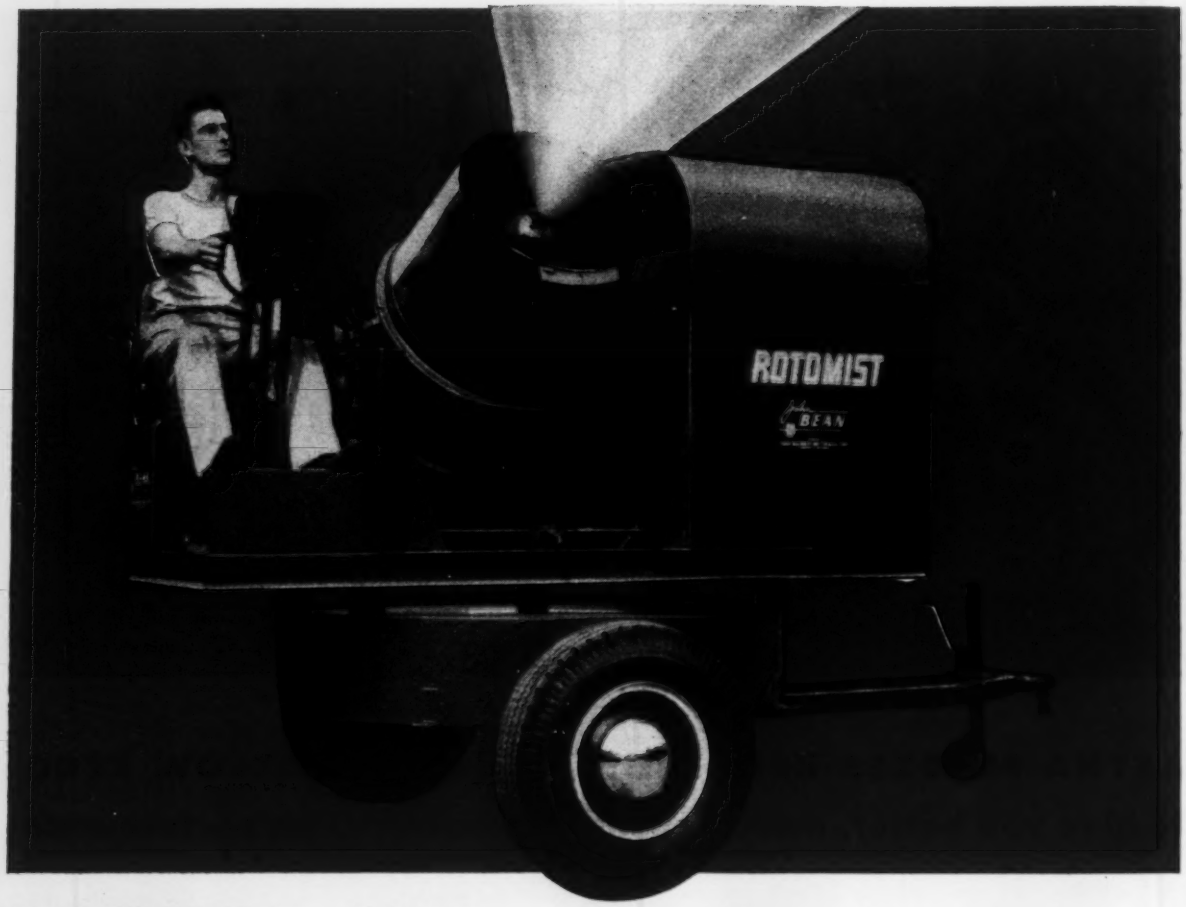
Circle 548 on page 19



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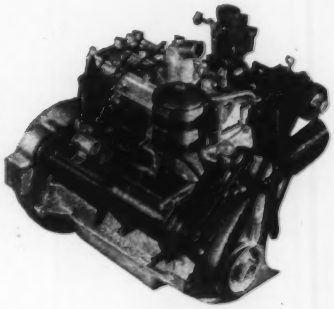
Rugged 'Jeep' power provides ready-and-steady low cost spraying

If the task calls for tough power in the 20-55 continuous hp range, it calls for 'Jeep' engine ruggedness. Parts that tend to wear out first in ordinary engines are reinforced in 'Jeep' 4-cylinder Industrial Engines, resulting in lower maintenance costs and longer engine life. When these attributes are teamed up with 'Jeep's' famous low fuel consumption, it's easy to see why these engines are noted for their exceptional economy. For spraying, irrigation, mobile equipment or any of a thousand jobs demanding rugged power... specify 'Jeep' Industrial Engines.



'Jeep' Industrial Engines are available as bare engines or power units. Send for 'Jeep' engine brochure giving full specifications.

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- **FORGED CRANKSHAFT** is dynamically and statically balanced and counterweighted for long life... smooth operation.
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4-cylinder engines... 20-55 hp (continuous)

WILLYS MOTORS, INC. — *Industrial Engine Department* — TOLEDO, OHIO

News about

B.F.Goodrich Chemical *raw materials*

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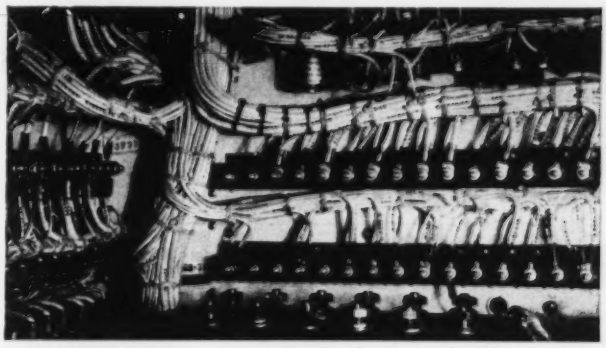

SUPERIOR INSULATION . . . Geon insulated wire is ideal for machine tools and similar equipment where wiring is exposed to oil and solvents. Non-flammability is important feature.

LONG-LASTING FILTER . . . this rigid Geon filter part used in corrosive plating solutions outlasted metal 6 to 1.

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GEON polyvinyl materials offer exceptional advantages . . . inertness or resistance to attack by most acids, alkalis, oils, and solvents, as well as water. Abrasion resistance is outstanding.

This versatile material can be extruded or molded into rigid products like piping, extruded into flexible products like insulation. Or it can be applied as a coating on metals or fabrics. Where you need exceptional durability and resistance use Geon. For complete information write Dept. DO-5, B. F. Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ont.

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MULTIMET alloy wraps are joined by welding in the fabrication of aircraft cabin heaters.

MULTIMET Alloy Wraps Absorb the Heat from a 3500 deg. F Flame

MULTIMET alloy wraps are used to absorb the intense heat from burning aviation gasoline in aircraft cabin heaters. The spirally wrapped alloy sheet transfers the combustion heat to fresh ventilating air. Very thin sheet — only 0.025 in. thick—does an excellent job here despite the high metal temperatures and the oxidizing conditions.

Rigorous 1,000-hr. tests were conducted before MULTIMET alloy was selected for this job. It has now been the standard material for seven years. The excellent high-temperature properties of the alloy made it possible for designers to use thin sections, which insure a light, compact heater, with excellent heat-transfer efficiency.

MULTIMET alloy is one of many HAYNES high-temperature alloys for economical use over a wide range of operating conditions. It has given good service for engine manifolds, turbine blading, heat-treating equipment and many aircraft components. For a copy of a booklet describing HAYNES high-temperature alloys, and for prices and sizes of MULTIMET alloy, get in touch with the nearest Haynes Stellite Company office.

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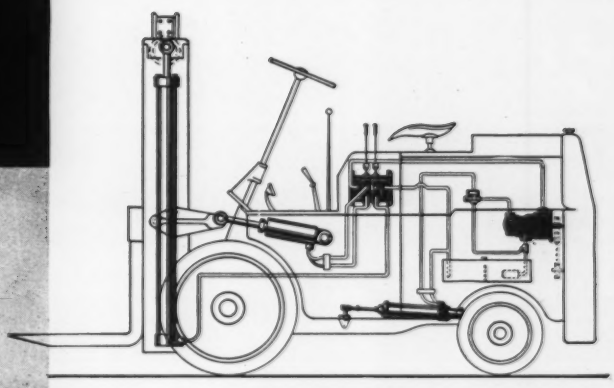
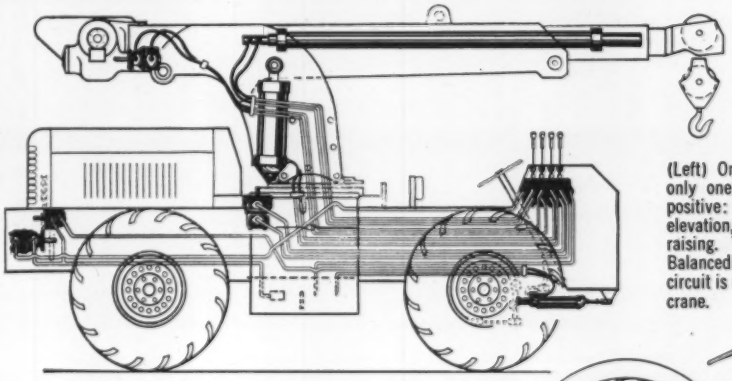
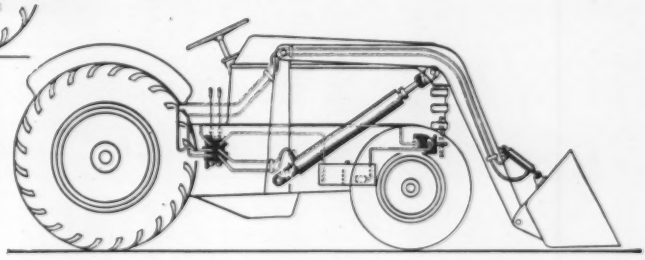
"Nobody sets a diamond in a brass ring." And when a manufacturer of materials handling equipment uses Vickers Hydraulics, it is indicative of superior quality throughout. To the inherent advantages of hydraulic control, Vickers adds the benefits of a nation-wide and full time field engineering and service organization of unequaled experience. Vickers has the complete line of hydraulic equipment necessary to take undivided system responsibility . . . to eliminate any risk of incompatibility of hydraulic components. For further information, ask for new Bulletin M5101A.



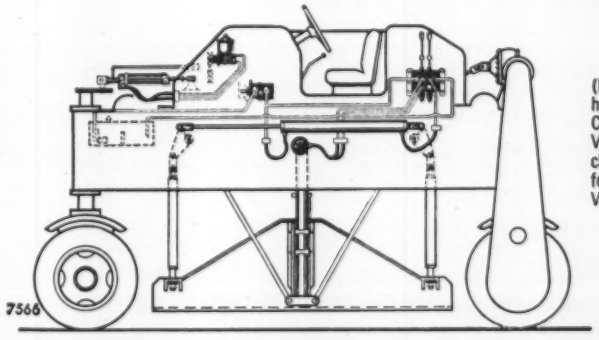
(Above) Fast tilting and lifting are possible along with exclusive "feathering" ability. Also, fingertip power steering permits operator to maneuver vehicle with one hand and control loading operations with the other. Additional vehicle attachments can be hydraulically controlled by simply adding sections to existing control valve eliminating necessity of mounting separate valves.



(Left) One Vickers Hydraulic System (using only one pump) provides fast, smooth and positive: (1) turntable rotation, (2) boom elevation, (3) boom extension, and (4) load raising. Turntable is driven by a Vickers Balanced Vane Type Fluid Motor. Another circuit is used for power steering this hydraulic crane.



(Right) Fast, easy and dependable operation of front end loader depends upon Vickers Balanced Vane Pump and Vickers Two-Section Directional Control Valve. Automatic wear compensation is inherent in all Vickers Balanced Vane Type Pumps. Note simplicity of installation.



7566

(Left) Straddle carrier uses hydraulic power to handle the load with precision and speed. Compact, two-section Vickers Multiple Unit Valve has double-acting valve for opening and closing load hooks and single-acting section for raising load. Separate circuit provides Vickers Hydraulic Power Steering.

WRITE FOR BULLETIN M5101A

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

ADMINISTRATIVE and ENGINEERING CENTER

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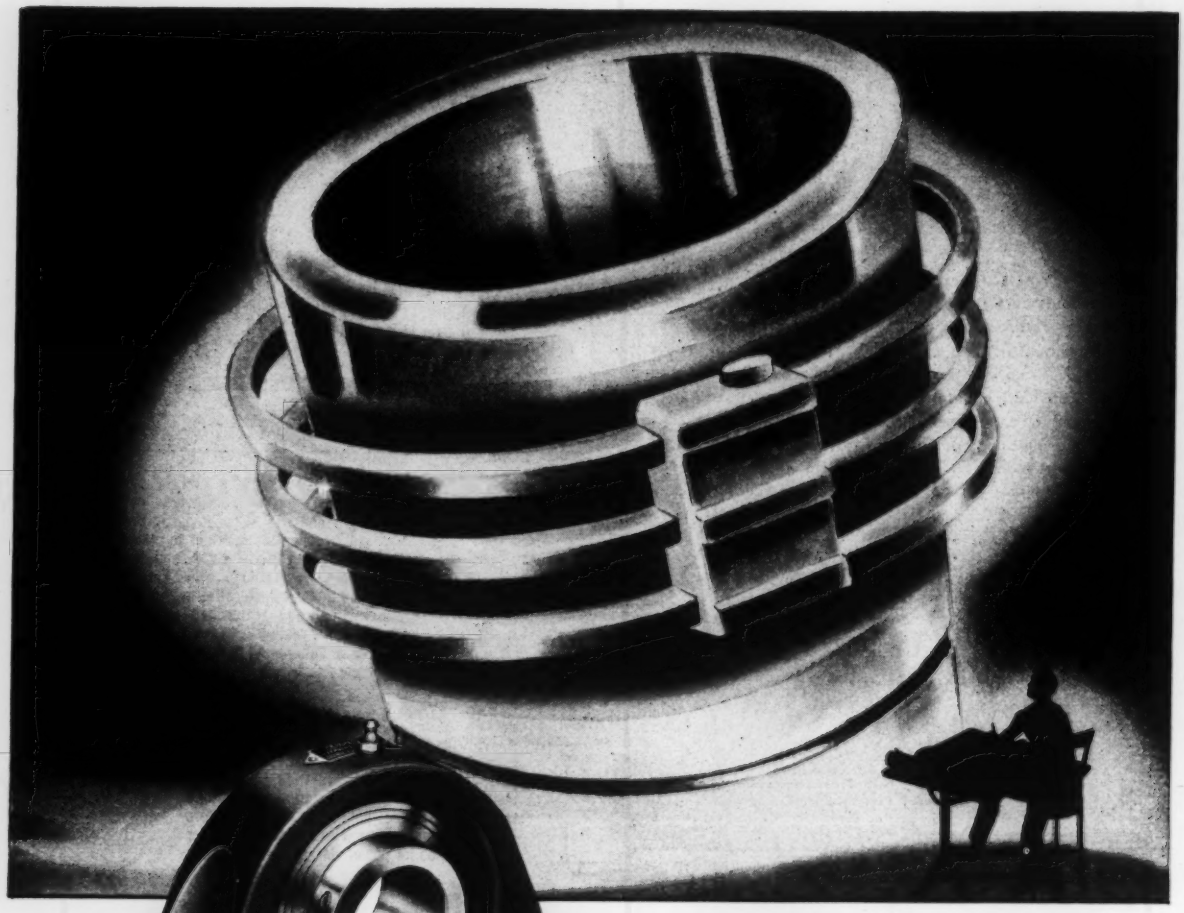
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



THIS ONE FEATURE *ALONE* MAKES SEALMASTER OUTSTANDING

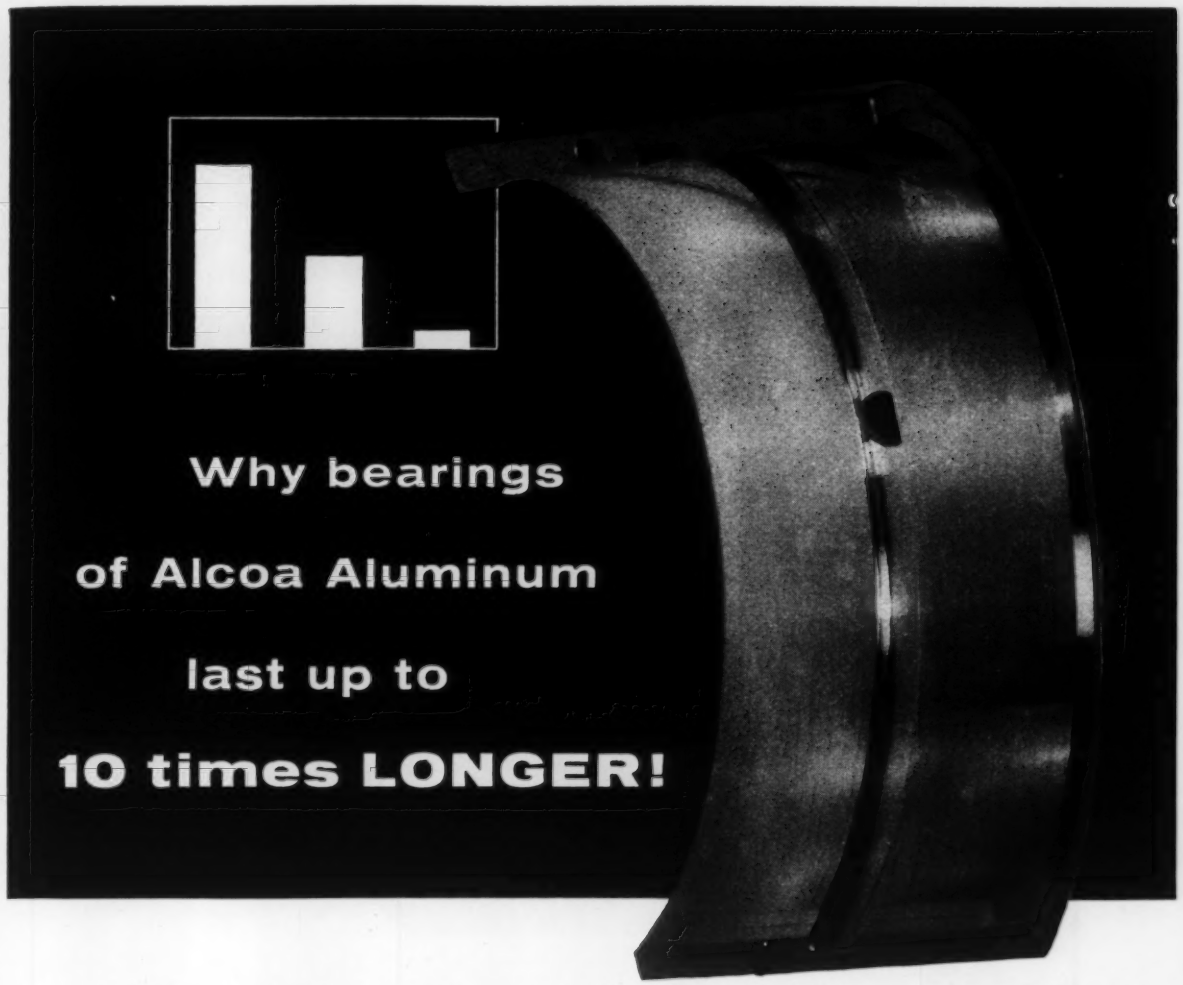
ZONE HARDENING

SEALMASTER Ball Bearing Units provide a patented exclusive feature, **Zone Hardening,** which assures a positive race to shaft lock. **Zone Hardening** is a completely automatic heat treating process by which the inner race ring of SEALMASTER Ball Bearing Units is hardened through the ball path and adjacent section only. The extended portion of the inner race is left in its original metallurgically soft, tough state. Hardened set-screws are mounted through this soft portion of the race, permitting race-to-shaft locking with increased holding power and greater resistance to vibration and shock.

You'll want full information on the advantages of this and other SEALMASTER features—such as Self-Alignment, Locking Pin & Perimeter Dimple, Labyrinth Seal, Floating Ball Retainer, etc. Write for Bulletin 454 today.

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 18 RIDGEWAY AVE., AURORA, ILLINOIS

Circle 553 on page 19



A leading diesel engine manufacturer increased the life of their crankshaft bearings *at least 10 times* by switching from babbitt to solid bearings of Alcoa® Aluminum. Bearings of Alcoa Aluminum are outperforming babbitt and bronze in hundreds of other applications—because aluminum has an *unmatched combination of advantages.*

Highest load capacity—Solid aluminum bearings withstand the highest loads—up to 10,000 psi on projected area in certain applications. Aluminum bearings are the only solid bearings suitable for heavy-duty service.

20° cooler running—Aluminum is the best heat conductor of *all* bearing metals. Result: aluminum bearings run up to 20° cooler than other bearings. Where hot spots are likely, there's far less danger of seizure.

Excellent conformability—Aluminum has good ductility, conforms readily to misalignment of shafts or nonparallelism of pins. This reduces unit loading, makes bearings last longer.

Handles dirt well—Dirt in the oil? Aluminum embeds particles far better than bronze, but not as deeply as babbitt. Dirt particles roll out of aluminum more easily and are trapped by the filter.

No corrosion problem—With its excellent corrosion resistance, aluminum is unaffected by additives in oils. No protective coatings are needed.

No failure damage—With solid aluminum bearings, there's no chance of journal damage in event of bearing failure.

Great design flexibility—The *structural* properties of Alcoa bearing alloys give you interesting design opportunities. For example, solid aluminum connecting rods which eliminate the need for insert bushings. Full-floating bearings. Water-cooled bearings with integral cooling passages.

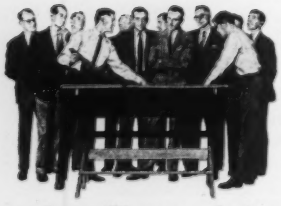
Carefully investigate cast bearings of solid Alcoa Aluminum. Check your bearing manufacturer or write: Aluminum Company of America, 1986-J Alcoa Building, Pittsburgh 19, Pennsylvania.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Your Guide to the Best in Aluminum Value

Circle 554 on page 19



The drafting stage—not later— is the time to design-in oil seals!

Oil seals are precision products. They are designed to operate under a specific set of conditions. Change just one of those conditions—lubricant, shaft speed, temperature, even bearing position—and a different seal will almost always be needed.

Why chance costly retooling or remanufacture? Specify the correct seal on the drawing-board. And when you do, get all the information there is on new seals, new lip compounds, and mechanical designs. Get it from your National Oil Seal Engineer. His counsel is complete, up-to-the-minute, and accurate. You couldn't buy better oil seal information, yet his help is yours for the asking.

Why "do it yourself?" Call the nearest National Oil Seal Engineer now.

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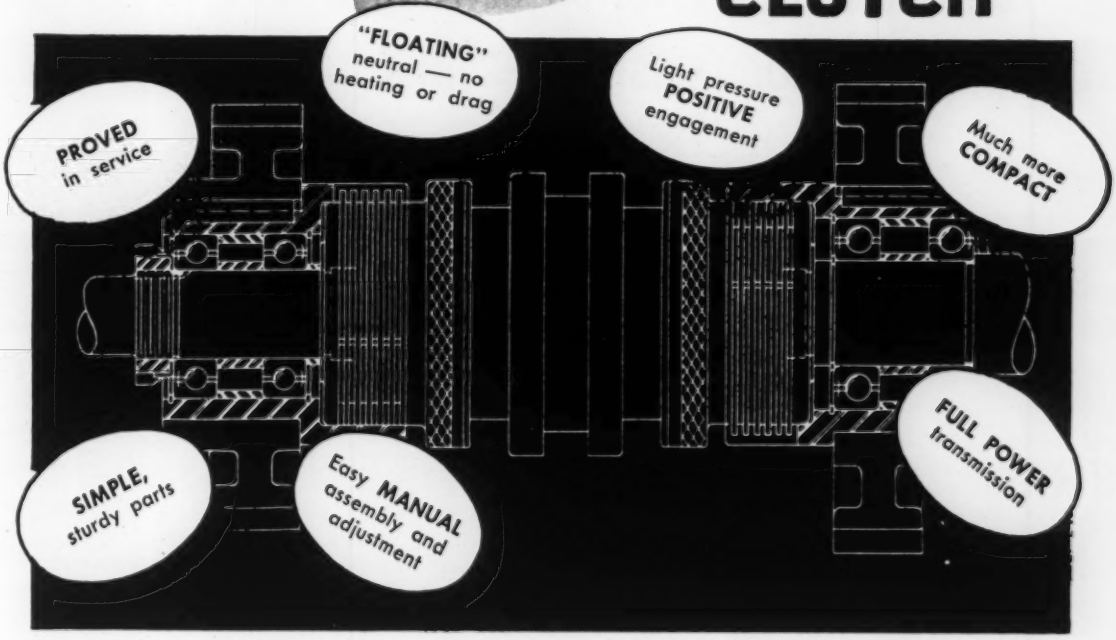
3880

BUILD INTO YOUR PRODUCT THE TROUBLE-FREE PERFORMANCE OF A

MAXITORQ

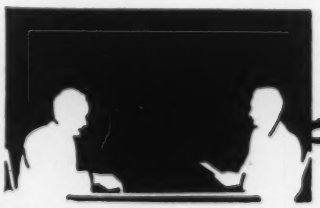
floating disc

CLUTCH


"FLOATING" neutral — no heating or drag
Light pressure POSITIVE engagement
PROVED in service
Much more COMPACT
FULL POWER transmission
SIMPLE, sturdy parts
Easy MANUAL assembly and adjustment

Here is an example of the simple, rugged, and compact installation possible with a MAXITORQ Double Clutch, with pulley-type driving cups, as the speed-change control between high and low-speed gears. Since MAXITORQ clutches, because of their exclusive design features, are always quick and positive in action while at the same time completely free in neutral, this type of installation has a well-proved record of performance to recommend it.

Other types of MAXITORQ Floating Disc Clutches . . . single, double, and overload release . . . are available in a wide range of stock sizes to meet the needs of a great many installations. Our engineering department also stands ready to help you with special drive problems. Write or phone Dept. MD-9. The Carlyle Johnson Machine Company, Manchester, Conn.



Let's talk **MAXITORQ**

7CJ33

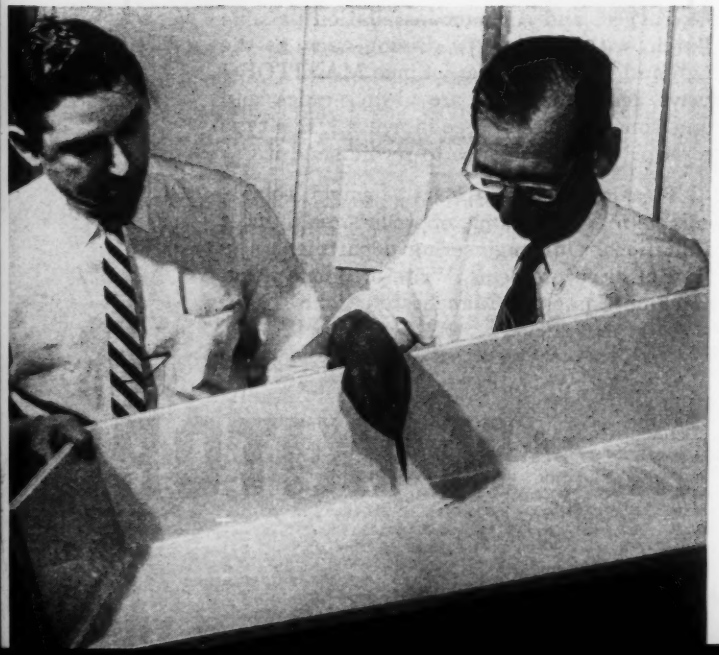
MONSANTO

In modern merchandising, product ideas are "where you find them." They come from the selling agent. They come from the manufacturer. In today's Plastic Age, more often than not, they originate in the design department of the custom molder. Read how one of America's foremost merchandisers teamed with a leading custom molder to translate the unique properties of a plastic material into a new departure in furniture design.

GE, Sears, and Lustrex styrene plastic open up new color possibilities in furniture

DESIGN OBJECTIVE: a drawer for chests and nightstands that offered new color possibilities, ease of manufacture, economy, durability, and ease of care—without sacrificing the warmth, beauty, and acceptability of wood.

MATERIAL SPECIFICATIONS. The Chemical & Metallurgical Division of General Electric Company, working with Monsanto specialists, designed the answer—a 3-sided drawer molded in one piece of Monsanto high impact Lustrex styrene plastic. The fourth side—the front—was to match the case.



GE selected high impact Lustrex for many reasons. Color, for one—an unusually wide and varied range of lustrous colors. Fast moldability. Toughness. Dimensional stability—drawers molded of Lustrex would resist swelling or warping. Lustrex offered design flexibility—the one-piece molding could incorporate top runners, center guide flanges, compartments, and dividers. And the wooden side could easily be attached.

Circle 557 on page 19

injection molding in 200 oz. presses at General Electric's molding plant at Decatur, Ill. The molding material was Monsanto Lustrex Hi-Test 88, a rubber-modified high-impact styrene.

THE FINISHED DRAWERS come in beautiful pastel molded-in colors. Their smooth rounded corners are easy to clean. There are no seams in the one-piece construction to dry out or spread. No additional finishing is required. The drawers fit snugly without fear of sticking in the cases made by Broyhill Furniture Factories, Lenoir, N. C., and Ward Furniture Co., Fort Smith, Ark., for Sears Roebuck. Featured in Sears' 1956 line of bedroom furniture, these drawers are making a major contribution to the growing trend to color in American homes today.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. The skill and experience of these 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Applications Dept., Room 608, Springfield 2, Mass.

Investigate the Monsanto completely-balanced line of styrene plastic compounds developed for particular applications and sold under the trade name . . .

LUSTREX
Styrene Plastic

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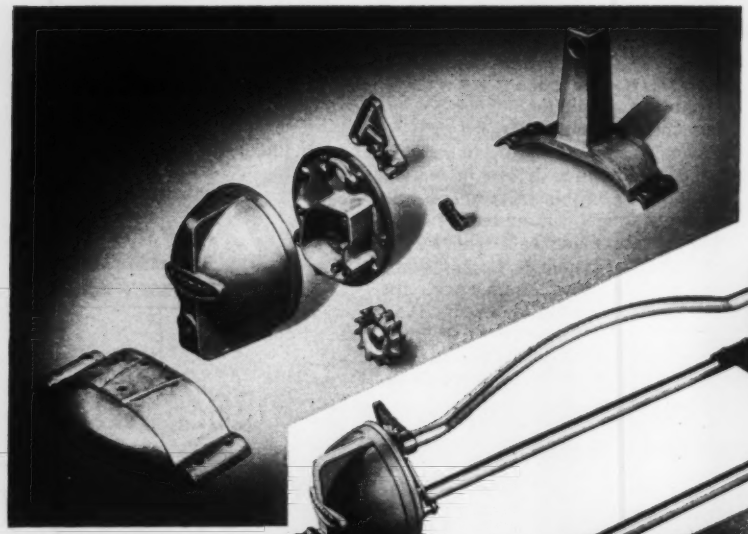


PRODUCTION SHORT CUTS WITH

ZINC

DIE CASTINGS

NUMBER 4 OF A SERIES

A back and forth motion of the Swingin' Spray sweeps a uniform rain-like spray over a rectangular area of up to 2400 sq. ft. Its "Perma-Sealed" motor unit completely separates the water flow from the motor. Grit and dirt stay out—lubrication stays in!

Covering the ground at MELNOR

Melnor's Swingin' Spray oscillating lawn sprinklers were designed to be sold with a year's unconditional guarantee. This means, of course, that they have been built to high engineering and manufacturing standards. Thus the selection of ZINC Die Castings for seven of the principal assembly components is of special significance.

Because of the unusual contours of the components illustrated, it is obvious that die casting is the most practical method of production. And, when all of the requirements of strength, weight and corrosion resistance were fully considered, Melnor engineers found that ZINC alloy was the metal that would do the job best—at lowest cost. All holes, recesses and projections are obtained in the casting operation, thus greatly minimizing secondary work prior to assembly, and the smooth, as-cast surfaces of four of the parts are easily and economically coated with bright yellow and dark green enamels.

Send for your copy

The production and sales advantages imparted to this motor-driven sprinkler by ZINC Die Castings are typical of those found in a wide variety of products. For 80 additional examples send for our booklet "The End Uses of Zinc Die Castings" and ask any commercial die casting company for die casting design assistance to improve *your* products.

ZINC
FOR DIE CASTING ALLOYS

The New Jersey Zinc Company, 160 Front St., New York 38, N. Y.

The research was done and the Zamak die casting alloys were developed with

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

Circle 558 on page 19

MACHINE DESIGN
SEPTEMBER 6, 1956

As Others See Us

THE engineer, by training and association, usually possesses a sound sense of values. He judges a man by qualities of character and intellect rather than by superficial behavior and appearance.

As a professional man, however, he must deal with a "public" —management people and his firm's customers—whose values may not quite coincide with his own. How they regard him is important to his professional standing.

In the thinking of such people outward appearance often rates highly. The well-groomed, well-dressed man with the brisk but cordial manner commands attention, as the learned professions have long recognized. The successful doctor or lawyer knows that such characteristics are half the battle in inspiring confidence in his professional competence.

In creating that good appearance, in turn, clothing is half the battle, as military people well know. How a smartly tailored uniform can transform a very ordinary-looking character into an imposing admiral or general is little short of miraculous.

A surprising number of engineers seem to have a blind spot when it comes to dress. So long as they work only in office, drafting room, laboratory and shop the need for maintaining a trim appearance may seem secondary. But, as our durable Stress Relief correspondent J. P. Henderson once remarked, "Before you can occupy an executive position your boss must be able to *imagine* you in such a job." Baggy pants or sports attire won't help the boss visualize a prospective manager.

An attractive "package" that will create the desired impression is not difficult to achieve. George Amber tells how, in a practical and unusual article beginning overleaf.

Perhaps engineers tend to believe, with Burns, that "a man's a man for a' that." But they should remember that there are many more who think, with Shakespeare, that "the apparel oft proclaims the man."

Colin Carmichael

EDITOR

A professional in any field can be identified by certain hallmarks—one of them being a competent, capable appearance. Dress is a big factor. People tend to judge the contents of a package by its wrappings, even in engineering. And an engineer's acceptance as a professional can be hampered by an unprofessional appearance. So, as a practical, everyday guide, here's an engineering approach to

Packaging the Engineer

By George H. Amber and Herbert R. Carrier

Professional Engineer
Detroit, Mich.

Engineering Writer
St. Clair Shores, Mich.

LOGICALLY or not, books are judged by their covers, and the appearance of a package reflects on the quality of its contents. So are men judged by their dress.

Contrary to the objective nature of most engineering concepts, "dress" is a subjective matter. It follows no absolute standards. Rather, it is based on the opinions and examples of others, and depends mainly on an artistic sense of propriety and correctness.

Although proper dress can't be analyzed mathematically, there is general agreement on the fundamental rules of good dress. This article attempts to present these basic principles; it also goes a long step further in presenting the many variables of year-round clothing in "data chart" form. These recommendations, although felt to be authoritative, are not iron-clad. The right outfit is, after all, a matter of individual opinion; regimentation is certainly not desirable.

Thus, it might be said that the one and only fundamental rule to go by in selecting clothing is, *don't take it too seriously!*

No one demands that an engineer be a "clothes horse" or display high style. And no claim is made here that the rate of professional advancement will show any marked improvement if the niceties of dress are observed. However, active disregard of personal appearance may hurt one's standing.

On-the-Job Requirements

Engineers' activities take them anywhere from Mahogany Row to the production line. This complicates the problem of selecting proper clothing for the particular engineering activity. A shiny trouser seat is the only hazard in the office. Field work, on the other hand, results in real wear and tear.

For the most part, the type of engineering work determines which types of clothing are best. *Fig.* 1 illustrates how the engineering activity influences not only suit selection but the complete choice of accessory items as well.

Principal variables in a suit are fabric (which includes the texture), pattern and color. The various patterns and colors available in most fabrics have little to do with fabric texture or physical characteristics. For the most part, the different fabrics are used to make up distinct classes of suits, such as dressy, utility and casual, *Table* 1.

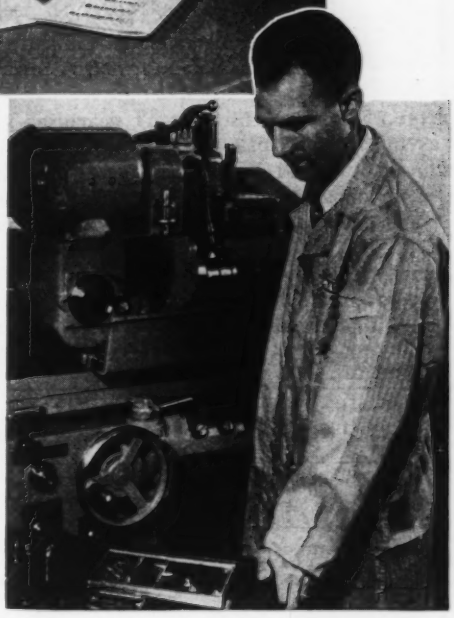
Dressy suits tend toward formality, but do not include formal wear. This type is worn when work is not rough and "casual" clothes don't seem to be appropriate.

Utility suits are the everyday—and often overworked—business suits, especially for exceptionally hard service. These are suitable for many engineering activities.

Casual suits are open, easy-fitting styles which stress comfort and informality. Some "sportswear" is actually casual attire. The "sport coat," properly accessoried, is actually casual attire and is usually acceptable for work.

Sports clothing is suitable to wear only while participating in sports, including spectator sports. True sportswear (which does not include the sport coat) has no place in the business field, but is reserved for off-hours.

Usually, one or more of the first three classes



of suits is suitable for particular engineering jobs, *Table* 2. The engineer who performs varied activities in the course of a single working day does have a problem. He may wrestle with a machinery layout problem in the morning, and then be at a staff conference in the afternoon. What, then, is this man to wear? Silk or dungarees?

The answer is: it is much better to wear clothes that are "too good" for the job than to create a poor impression.

Economically, of course, suits can't be considered expendable. But circumstances may make some accelerated wear and tear honorable occupational risks of the engineering profession.

On the other hand, if things actually do get rough, then don a clean protective shop coat or coverall. Don't fall into the trap of using old clothes as work clothes.

The trend nowadays is definitely toward the increased use of "easy" casual clothing. This is good. Natural inclinations toward increased comfort are finally being recognized as being entirely proper for both on-the-job situations and after hours. However, more dressy clothes should be worn when they are definitely called for; that is, in the front office, at official functions, dinners, etc.

But for most occasions, convention, good taste and comfort can go hand in hand through the use of casual wear, including the sport coat and contrasting slacks outfits. But here again, beware of going overboard. Actual sportswear is not suitable for the office.

In any basic engineering wardrobe, at least one utility suit should be included. The old reliable utility suit has one major advantage. It wears well. Too well, if anything, causing it to be worn long after it has earned honorable retirement. But for the lab, shop or field, consider the utility whipcord twill using Australian yarn as a valuable asset. These are called "bullet-proof suits" by the trade. Utility worsted will take a lot of abuse and look good for a long time.

One final word on the utility suit. From a mechanical viewpoint, the suit is superb. But it is inclined to be a bit bulky and stiff, and it usually doesn't "drape" well. It shouldn't be worn on all occasions just because it has a good score in the textile test laboratory.

Any engineer's basic wardrobe can profitably include a well-cut woolen suit with patch pockets,

such as a tweed or shetland; also a pair of dark brown shoes with medium-weight soles. The casual, soft woolen suit coat can readily double as a sport coat, and the shoes can pinch hit to go with any outfit.

Furthermore, the "mixability" of suit coats, sport coats, slacks and trousers help spell one over those inevitable days when a favorite suit is at the dry cleaners. Two-pants suits, too, help out here.

Selecting Accessories

"Accessories" generally refers to shirts, socks, ties, hats, gloves and mufflers. Their selection in the what-to-wear problem depends upon the suit to be worn for the particular occasion. Once the appropriate suit has been determined, the accessories are chosen to complement each other, as well as the suit, so as to present an integrated, harmonious appearance.

Different suit patterns, types of fabrics and designs go best with specific shirt-sock-tie combinations as shown in *Tables* 3 and 4. Colorwise, *Table* 5, the shirt is selected to complement the suit, and then the tie is selected to complement the shirt.

Shirts: Fabrics for shirts aren't nearly as variable as fabrics for suits. Oxford, white-on-white, batiste, madras and broadcloth just about take care of any business type shirt. Collar and cuff types, and color, are the most usual variations in shirts.

Normally, shirt collars run regular, button-down, and widespread. The style worn is pretty much a matter of personal taste. For general business wear, button-down, widespread or regular collars are all acceptable. For dressy wear, however, the choice narrows down to the regular collar. Casual wear takes well to button-downs and textured shirt fabrics.

Shirt cuffs can be either French or barrel, with French cuffs gaining in popularity. They are fine for the drafting room for they are easier to roll up. For the dressier front office look, the French cuff is almost a must.

No longer is white the only acceptable shirt color for business. Pastels are rapidly becoming popular

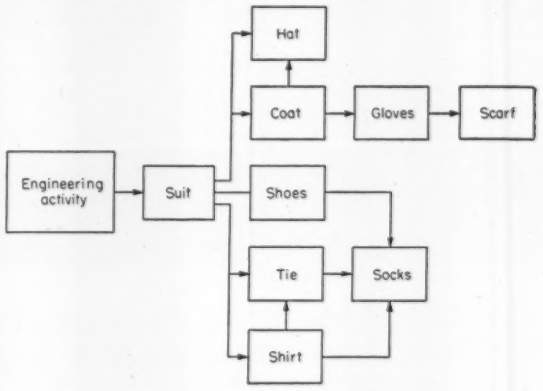


Fig. 1 — Influence of engineering activity on suit choice and on selection and combination of accessories

Table 1—Types and Characteristics of Suit Fabrics

Class	Type	Fabric	Wearing Characteristics	Description
Dressy: Pinstripes; dark blues; charcoals; grays; browns; "tailored fit"	Fine, smooth finished worsteds; twill weave	**Cashmere**	Poor	Light; soft; loose-textured; "luxury" fabric
		Gabardine	Hard	Holds crease; may get shiny; may have worsted finish
	Soft, napped worsteds; plain weaves	**Worsted flannel**	Fair	Stronger and longer wearing than plain flannel
		Unfinished worsted	Good	Soft; smooth; closely woven; lightly napped
		Worsted cheviot	Hard	Semifinished; doesn't get shiny; has nap
Utility: Patterns; stripes; all colors and shades; splash weaves	Hard, smooth - finished worsteds; twill weaves; woolen	**Sharkskin**	Good	Neat; sturdy; plain, striped or patterned
		Whipcord	Hard	Very tough; stiff; "bullet-proof" twill; Australian yarns
		Twist	Hard	Very tough; resilient; holds its shape
Casual: Herringbones; nubby; all colors and surface effects; contrasting or matching coats and trousers; "sport" jackets; loose fit	Woolens; plain weaves	**Woolen flannel**	Fair	Buttery nap; springs back; nap wears easily
		Homespun	Good	Heavy; basket surface; resists wrinkles; good traveler
	Patterned and worsted tweeds	**Tweed**	Good	Rough; bulky; may bag or stretch if not of good quality
		Shetland	Good	Soft; lighter weight than tweed; ideal for sport coats
		Covert	Hard	Soft; smooth nap; resembles coarse gabardine
		Woolen cheviot	Good	Nap harder and coarser than regular tweed
		Herringbone	Good	Available in worsteds and tweeds; comfortable to wear
		Striped twist	Hard	Durable; holds shape; long-wearing; casual

and commonplace. Also, solids and checks are usually considered legitimate in all but dressy office wear.

Socks: In general, socks match the tie (predominant color), or the shoes or suit. The more dressy the suit, the less "loud" the socks. Argyles or diamond patterns don't go too well with conservative suits. However, they are okay with the sport coat and contrasting slacks outfit, and with other woolens.

Shoes: Selection of shoes can be classified into the *dressy* and *casual* categories. Heavy soled brogues are most commonly worn with a casual outfit and utility suits. Dressy executive wear calls for thin-soled black or dark brown shoes. The new low cuts don't belong in shop or lab. They just can't take the gaff. Cordovan is the "cast iron" shoe; it can't be excelled for wear.

Hats: Men's hats never seem to get the attention they deserve. Facial contour and head shape is just as important as the correct head size. Brim width and crown shape vary widely as facial and head shape demand. Hats should be selected carefully to complement the head and to fit the balance of the wardrobe. Don't be afraid to wear the new narrow-brim hats. The shape of the crown compensates for the smallness of the brim. The snap-brim is an old reliable "universal" hat. But an additional alternate style can help liven up a wardrobe.

Ties: Here, perhaps, is the "Achilles heel" of dressing. Proper tie selection and knot can make or break the whole effect of good grooming. An eye for a tie, plus the ability to knot it properly, is an asset. The color chart, *Table* 5, will help select the proper tie to wear, but only practice can furnish a good-looking knot. There are three methods of knotting ties: four-in-hand, windsor, and bow knot, and each serves a specific purpose.

The four-in-hand goes well with the regular shirt collar. The windsor looks best with the widespread collar, and the bow tie creates the neat, young look, or can be used when the four-in-hand may get dragged across the drawing board or wrapped around a high-torque motor shaft.

Table 2—Suit Types for Engineering Activities

Engineering Activity → / Suit Type	Executive Activities	Public Relations Activities	Sales	Conventions	Contact work	Liaison	Society meetings	Evening functions	Design and Development	Engineering office	Drafting room	Board work	Field Work	Laboratory and Factory	Laboratory	Factory: supervision	Factory: heavy or dirty
Dressy																	
Cashmere	X																
Mill finished	X		X					X									
Gabardine	X		X	X	X	X	X	X		X	X	X					
Worsted flannel	X		X	X	X	X	X	X									
Unfinished worsted	X		X	X	X	X	X	X		X	X	X	X		X	X	
Utility																	
Worsted cheviot							X					X	X		X	X	
Sharkskin			X	X	X	X	X			X	X	X	X		X	X	
Whipcord												X	X		X	X	
Twist												X	X		X	X	
Casual																	
Woolen flannel			X		X	X				X	X	X					
Orlon flannel			X			X				X	X	X					
Homespun					X	X				X	X	X					
Tweed			X		X	X				X	X	X					
Shetland										X	X	X					
Covert										X	X	X					
Woolen cheviot					X					X	X	X					
Special																	
Protective clothing															X		X

General rule: Rough duty requires stronger, more durable fabric.

Table 3—Accessories for Suits

Suit Types and Fabrics / Accessory Style →	Shirts: Madras	Broadcloth	White on white	Oxford cloth	Basketweave	Sport shirt	Socks: Solid	Ribbed	Clocked	Scattered	Diamond	Plaid	Argyle	Heavy knit	Ties: Foulard	Jacquard	Crepe	Grenadine	Nubby	Basketweave	Wool	Knitted	Hats: Homburg	Upturned brim	Narrow brim; tapered crown	Snap brim	Porkpie	Tweed	Tyrolean
Dressy																													
Cashmere	X		X	X			X	X							X	X		X			X	X	X	X					
Mill finished			X	X			X	X	X						X	X		X			X	X		X					
Gabardine	X		X	X			X	X	X						X	X	X	X	X		X	X		X	X				
Worsted flannel			X	X	X		X	X	X	X	X				X	X	X	X	X					X	X	X			
Unfinished worsted	X		X	X	X		X	X	X	X	X				X	X	X	X	X			X		X	X	X			
Utility																													
Worsted cheviot		X		X	X		X	X	X	X	X			X	X	X	X	X		X				X	X	X			
Sharkskin		X		X	X		X	X	X	X	X			X	X	X	X	X		X				X	X	X			
Whipcord		X		X	X		X	X	X	X	X			X	X	X	X	X		X				X	X	X			
Twist		X		X	X		X	X	X	X	X			X	X	X	X	X		X				X	X	X			
Casual																													
Flannel		X			X	X	X	X	X	X	X	X	X	X				X	X	X	X	X				X	X	X	X
Homespun		X			X	X	X	X	X	X	X	X	X	X				X	X	X	X	X				X	X	X	X
Tweed		X			X	X	X	X	X	X	X	X	X	X				X	X	X	X	X				X	X	X	X
Shetland		X			X	X	X	X	X	X	X	X	X	X				X	X	X	X	X				X	X	X	X
Covert					X	X	X	X	X	X	X	X	X	X				X	X	X	X	X				X	X	X	X
Woolen cheviot		X			X	X	X	X	X	X	X	X	X	X				X	X	X	X	X				X	X	X	X

Suit Types and Fabrics / Accessory Style →	Shoes: Plain cap	Military	Wing-tipped	Straight	Brogue	Crepe sole	Loafer (tied)	Moccasin (laced)	Low-cut	Coats: Bal raglan	Box; set-in sleeve	Fitted dress	Tweed	Gabardine; bal raglan	Rain combination	Gloves: Mocca	Pigskin	Capeskin	Nylon	Rabbit-lined	Knitted	Mittens	Scarves: Silk	Patterned	Knitted
Dressy																									
Cashmere	X	X	X						X			X				X							X		
Mill finished	X	X	X	X					X			X				X							X		
Gabardine	X	X	X	X							X					X							X		
Worsted flannel	X	X	X	X						X						X							X		
Unfinished worsted	X	X	X	X						X						X							X		
Utility																									
Worsted cheviot			X	X	X					X					X		X	X	X					X	
Sharkskin		X	X	X	X						X				X		X	X	X					X	
Whipcord		X	X	X	X								X	X	X		X	X	X					X	
Twist		X	X	X	X								X	X	X		X	X	X					X	
Casual																									
Flannel				X	X	X	X			X	X									X	X	X		X	X
Homespun				X	X	X	X	X		X	X									X	X	X		X	X
Tweed				X	X	X	X	X		X	X									X	X	X		X	X
Shetland				X	X	X	X	X		X	X									X	X	X		X	X
Covert				X	X	X	X	X		X	X									X	X	X		X	X
Woolen cheviot				X	X	X	X	X		X										X	X	X		X	X

Basis for selection on sh'rts, socks, ties, coats, gloves, and mufflers and scarves is mainly on surface texture, using the general rule that textured materials go well together.
Style is chief criterion on shoes and hats with following general rules: (1) dress suits require dressy accessories and casual suits, casual accessories; (2) utility suits require compromise accessories; and (3) thick-soled shoes go with casual attire.

Style, Color and Price

Style, *per se,* is a loose, relative term. What is style one year may be old-fashioned (or even comical) a short time later. The secret of being "in style" is to be alert to the general trends, and try to go along with them. Avoid dress eccentricities. Radical style changes are usually short lived, therefore, fad clothes are expensive when figured on a cost per length of time worn basis.

Color: Men's clothing is now more colorful than ever before. Perhaps as much attention is now given to color as is given to cut or design. The same policy applies to color as to styles. Go along with the general trend, but avoid the radical.

Budget: Clothing expense for an engineer may range from about 3 per cent of annual income for junior engineers and recent graduates, to about 4 per cent for men of the $10,000-a-year class. Dressing well doesn't cost less than the "top of the pile" method, but the modest increase in cost is well worth it. And knowing what to buy helps get much more value for the money. Suggested basic wardrobes for two types of engineering work are shown in *Tables* 6 and 7.

Quality Versus Price: Price cannot be the only guide in making engineering or personal purchasing decisions. It is the slope of the price versus value received curve that counts.

Garments—especially suits—have hidden quality

features built into them. Details of these quality features, and pointers on workmanship, are covered in the *Bibliography*.

Naturally, nobody can become an expert in judging quality of men's clothing by merely browsing through a few pamphlets. But here are some tips on how to size up quality in a garment in a hurry.

Quality features usually go together. If the surface details stand up under close inspection, the manufacturer has probably taken equal pains with the hidden features, such as pads and under-construction.

Concentrate on the "minor" details, such as buttonholes, stitches per inch, pockets and pocket linings, how buttons are sewed on, pattern matches, work under collar, and sleeve-coat intersections. Squeeze the pads, and roll up a lapel. Naturally, the number of threads per inch (the more, the better), number of threads per button, absence of loose threads, softness of pads, resiliency of under-construction, and smoothness of fit are all criteria of quality.

Fabric is most important, but the same fabric may be used in a suit selling at $69.50 or $85; it's the "guts" on the inside that determine how it will feel or wear.

It is a good idea to bracket a price range before buying. Pass up, if possible, the $28 special —also the $155 bench-tailored, hand-made suit.

Price usually dictates quality. The $28 suit may give value, but it is far inferior to say, a $70 one. And the suit with the higher dollar sign usually costs far less per day. The best bet is to buy as

Table 4—Accessory Patterns

Accessory Patterns → Suit Patterns	Shirts					Socks						Ties					
	Whites	Solids	Patterned	Checked	Stripes	Small figures	Blazers	Full argyle	Plaid	Side argyle	Knit-in stripe	Clocked	Solid color	Overall	Geometric	Plaid	Polka dot	Stripes	Scattered	Neat, small	Solid color
Solid	X	X			X	X	X	X	X	X	X	X	X		X		X			X	X
Hairline	X	X			X			X	X			X	X	X	X	X	X	X	X	X	X
Diagonal twill		X	X	X	X	X							X	X	X	X	X	X	X	X	
Plain weave		X			X	X		X	X	X		X	X	X	X	X	X	X	X	X	
Peppered		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Honeycomb		X			X	X					X		X	X	X	X	X	X	X	X	X
Knubby		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pin stripes	X	X		X	X						X		X	X	X	X	X	X		X	X
Birdseye	X	X		X	X	X					X		X	X	X	X	X	X	X	X	X
Nailhead	X	X		X	X	X					X		X	X	X	X	X	X	X	X	X
Herringbone	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Houndstooth	X	X			X		X	X	X			X	X					X	X	X	X
Glen plaid	X	X			X					X	X	X						X	X	X	X
Tartan	X	X			X					X	X	X						X	X	X	X

General Rules:

1. Like patterns clash.
2. Go easy on patterns; one strong pattern will do.
3. Excessive solid colors are dull.
4. Solids and patterns harmonize.
5. Heavily patterned socks go best with casuals.
6. A crisp tie with clean, strong patterns (no florals) helps set the style.

Wool—Synthetic Blends and Mixtures

For the most part, wool is still the basic material used for men's "year-round" suitings. Over 90 per cent of men's year-round suits are 100 per cent wool. But, although pure wool is a highly satisfactory fiber even when used without additives, it has one objectionable property, excessive shrinkage. To overcome this undesirable characteristic, various synthetic fibers are used with wool, such as Orlon, Dacron and nylon. Depending on the "alloying element" (which is usually a synthetic fiber) and how it is used, the resulting fabric made up of wool and the added synthetic fiber in combination can achieve remarkable improvement in such properties as shrinkage resistance, wrinkle resistance, "drape" and mechanical strength.

There are also nonwool suitings. These, however, are practically always used for summer, not year-round, apparel. An important exception is silk, a natural fiber. It is used as though it were a synthetic to add specific properties to a wool suit.

In *Table* 1 of this article, the characteristics described pertain to the basic 100 per cent wool suit. Whenever the suit material is a blend of wool plus a synthetic (or silk) the characteristics of the blend must be added to those listed in *Table* 1.

The following table lists the most common wool-synthetic (and silk) blends, their salient characteristics, and the ratio of wool to added fiber that develops the characteristics listed. This ratio is most important. Insufficient synthetic (or silk) results in negligible advantages. If an excessive amount of added fibers is added, the proved advantages of wool are lost. Add these properties to those in *Table* 1 for a complete description of such blends.

As already mentioned, nonwool fabrics are commonly used for summer suits. Such fabrics and suits are not included among the "year round" garments described in this article.

Blend or Mixture	Characteristics
Dacron-wool (55 per cent Dacron)	Improved wrinkle and abrasion resistance, even when wet. Long wearing. Negligible shrinkage.
Rayon-wool	Tends to wrinkle. Good strength. Comfortable. May stretch. Not recommended.
Nylon-wool	Holds shape well. High mechanical strength. Little used for year-round suiting.
Orlon-wool (30-50 per cent Orlon)	Excellent mechanical properties. Used for casual suiting. Soft buttery nap.
Silk-wool	Has surface interest. Improved crease and shrinkage resistance. Excellent drape. Light weight. Tougher than usually thought.

Table 5—Colors for Accessories and Suits

Accessory Colors → / Suit Colors	Shirts: White	Blue	Gray	Green	Tan	Yellow	Pink	Ties: Navy	Blue	Maroon	Black	Gray	Red	Brown	Green	Yellow	Socks: Black	Navy	Brown	Maroon	Blue	Green	Gray	Tan
Blues																								
Blue	X	X	X					X	X	X			X					X		X	X			
Blue-gray	X	X	X					X	X	X			X					X		X	X			
Browns																								
Tan	X			X	X	X				X			X	X	X	X			X	X		X		X
Beige	X	X		X	X	X				X			X	X	X	X			X	X		X		X
Cocoa	X			X	X	X							X		X	X						X		X
Chocolate	X			X	X	X								X	X	X			X			X		X
Charcoal brown	X		X	X		X				X				X	X				X	X		X		X
Greens																								
Green and black	X		X		X	X					X				X		X					X		
Ivy green	X		X		X	X								X	X				X			X		
Charcoal green	X		X		X	X								X	X				X			X		
Grays																								
All shades	X	X	X	X			X		X		X	X					X						X	

Accessory Colors → / Suit Colors	Shoes: Black	Cordovan	Dark brown	Club brown	Wine or oxblood	Tan or natural	Hats: Black	Dark brown	Brown	Gray	Tan	Green	Coats: Black*	Brown*	Navy	Gray	Tan or fawn	Gloves: Cork	Tan	Gray	Black	Navy	Maroon	Scarves: White	Yellow	Tan	Blue
Blues																											
Blues	X			X			X	X					X		X	X					X	X	X	X	X		X
Blue-gray	X		X		X		X	X					X		X	X				X	X	X	X	X	X		X
Browns																											
Tan		X	X	X		X		X	X		X	X		X		X		X	X					X	X	
Beige		X	X	X		X		X	X		X	X		X		X		X	X					X	X	
Cocoa				X	X			X	X		X	X		X		X		X	X					X	X	
Chocolate			X		X			X	X		X	X		X		X		X	X					X	X	
Charcoal brown		X	X	X				X	X		X			X				X	X				X	X	X	
Greens																											
Green and black	X		X	X	X			X	X				X	X	X							X			X	X	
Ivy green	X	X	X	X	X			X	X			X	X	X								X			X	X	
Charcoal green	X		X	X	X			X	X			X	X	X								X			X	X	
Grays																											
All shades	X	X	X					X	X		X		X			X				X	X			X			

General Rules:
1. Sock color should match shoes, suit or tie.
2. Shirt may be white or may complement the predominant colors of suit.
3. Tie should match or complement predominant colors of suit or shirt.
4. Discords, such as combinations of blue and green, should be avoided.
5. Brown shoes are preferred with brown, green or charcoal suits; black or very dark brown with grays and blues.
6. Hats match or complement suits. If coat is worn, hat matches coat.

*Including charcoal tones.

good a grade as possible, avoiding the most perishable luxury fabrics.

This doesn't mean that there aren't real price reductions of 20 per cent or so at the end of seasons, and it is well to watch for them. The $10 summer straw hat can be bought for $5 in late August. But the perpetual "half price" chant is a come-on.

Comfort and Personal Efficiency

An important objective of casual clothing is comfort—a recognized aid to personal efficiency. Any item of clothing that hampers activity is the wrong thing to wear.

Buildings are more likely to be overheated than underheated nowadays. And automobile heaters really throw out the Btu's. So suits are becoming lighter—a point to remember. Many a man finds that it is comfortable to wear light-weight and even tropical summer suits all year round. Conversely "year-round" suits, which imply cool weather, are frequently worn in hot weather if light in weight and, what's more important, if the working location is air conditioned.

If the weather is cool, however, a neat slipover sweater is entirely appropriate, either worn as a "vest," under a suit coat, or without a coat. A sweater can also make it unnecessary to wear a top coat in marginal mild to chilly weather.

Most men wear neckties. The best that can be said for this ancient custom is that in cool weather it is tolerable. But there are certainly times when a tie is a bother and a nuisance. No one can get away with wearing an ordinary shirt, *sans* tie. But there are dignified, well-cut shirts (not wild

Table 6—Suggested Basic Wardrobe: Office and Drafting Room Work

Suits:

Dressy: Worsted flannel or unfinished worsted.

Utility: Not necessary for this type of work.

Casual: Tweed or shetland suit, preferably patterned. Suit coat should be loose cut so it may be worn with solid-color contrasting slacks.

Accessories:

Should be chosen with an eye toward the overall wardrobe. Shirts, for example, should go with any suit or combination. Shoes also fit the overall scheme as well as the feet. Any expansion of the basic wardrobe adds to more extensive use of existing clothes. Try not to purchase items that will have only one specific use since this limits the wardrobe and makes proper dressing expensive.

Table 7—Suggested Basic Wardrobe: Travel, Laboratory and Field Work

Suits:

Dressy: Worsted flannel or unfinished worsted.

Utility: Whipcord twill, sharkskin, or twist.

Casual: Loosely tailored patterned tweed or shetland. Suit jacket to be worn with contrasting solid color slacks as a change.

Accessories:

"Middle-of-the-road" policy for accessory selection. Pick out accessories that are flexible and can be worn with all items, or at least most items, of the existing wardrobe. Avoid radical, one-combination type of outfit. Consider the synthetic blends for "good traveling." They usually are very easy to keep up.

ones) that can be worn either with or without ties. Tieless shirts go best with soft suits or very light tropicals, not hard, year round worsteds.

Under conditions where no tie is justified, short shirt sleeves are acceptable.

Health must not be slighted for style, whim or caprice. Hats and raincoats have a purpose. And there is no sense in wearing damp shoes all day if overshoes would have kept them dry.

No one especially likes cold winter weather, but it can't be ignored. So it is either the right heavy overclothing or a chat with the West Coast aircraft-industry recruiter the next time he is in town. There is no need to use a fathom of muffler and to bundle up like a Siberian refugee. But wear the right cold-weather gear.

Making Room for the New

A minor problem exists in the disposal of old apparel. Frayed shirts, scuffed-up shoes and tired old suits are a liability. A professional man can't afford to wear such items. And like machinery, obsolescence may enter the picture before the factors of wear and tear do.

Don't try to be a personal one-man test laboratory, determining how much a garment can take before it falls apart. Being *too* practical here can hurt one's reputation. Any visible repair to clothing, such as old buttons and patches, do not spell success.

ACKNOWLEDGEMENT

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industrial design Ideas

use the elbow room

IN a previous piece, I mentioned the importance of keeping machine floor space at a minimum, not only to reduce manufacturing costs, but also to gain a sales advantage. I'm not reversing my stand when I say that it's often impractical to set your "minimum" too low.

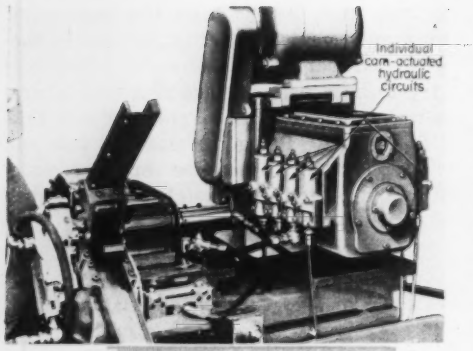
If an operator uses your product, let him establish the minimum floor space. He's at least a couple of feet wide, and he needs elbow room besides. Why, then, make your machine narrower than he is? And you'd be surprised to find out how often you can reduce costs and improve operation by using this allowable minimum.

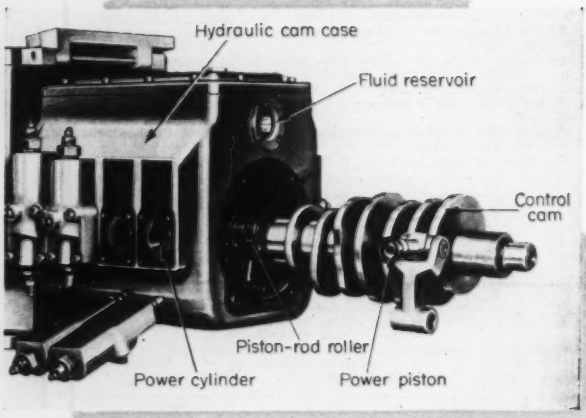
This same type of revised thinking about small machines can be applied to large machines too. Recently I did an industrial design job on an automatic screw machine. The bar and stock reel certainly constituted "floor space" just as much as the machine itself. We solved several design problems by merely extending the base of the machine several inches under the stock reel. The result—a more rigid base, a better proportioned and better looking machine, no increase in cost or floor space.

Perhaps this shows that the practical "maximum" is usually the best "minimum".

—Cliff

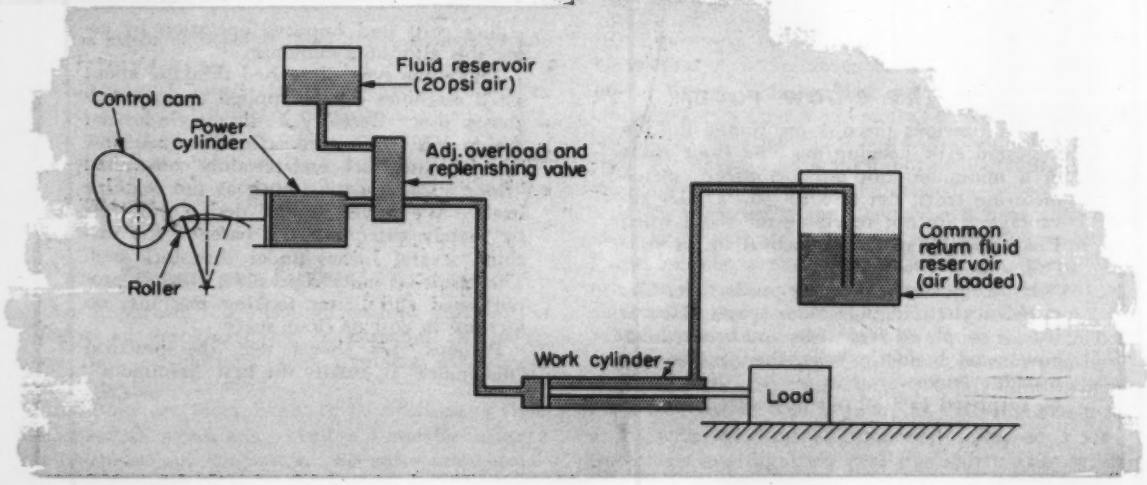
scanning the field for Ideas

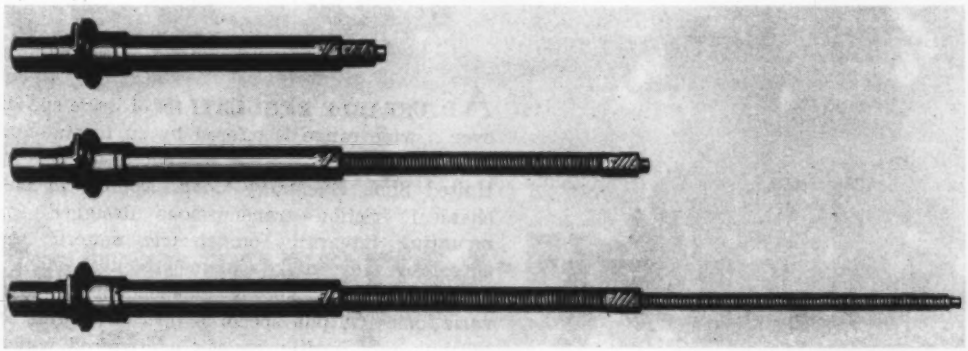




FLUID LINKAGES for control of machine performance combine features of mechanical and hydraulic operation in cam-follower systems. Used to transmit mechanical power and control motion from a centralized hydraulic control unit developed by the Earl A. Thompson Mfg. Co., these linkages consist of one or more independent fluid circuits which are sealed under pressure. At one end of each circuit is a power cylinder and at the other a work cylinder. In each power cylinder is a power piston driven by one of a series of cams mounted on a common shaft. The piston in the work cylinder is connected to the load. Cam contour, size, and mounting position determine timing and sequence of motions as well as length of stroke, within power cylinder limitations.

Each power piston is automatically returned by energy stored in a hydraulic accumulator during the power stroke. This hydraulic "spring-return" feature always keeps each cam-follower, which is in the form of a roller on the end of the piston rod, in contact with its cam and permits positive cam control of motion in both directions.



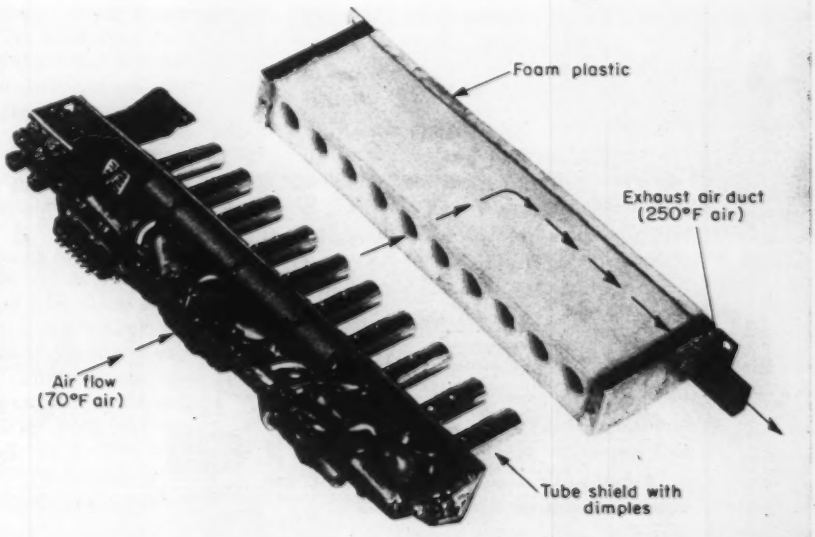


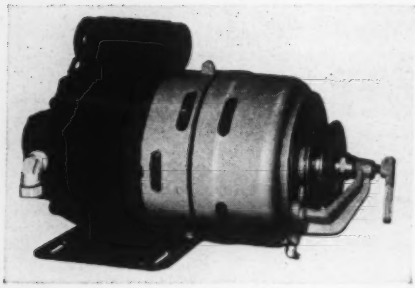
EXTENDIBLE BALL-BEARING SCREW offers a compact assembly for transmission of linear motion under limited space conditions. Developed by the Saginaw Steering Gear Div., General Motors Corp., the unit employs two or more ball-bearing screw and nut assemblies of diminishing diameter to permit concentric assembly.

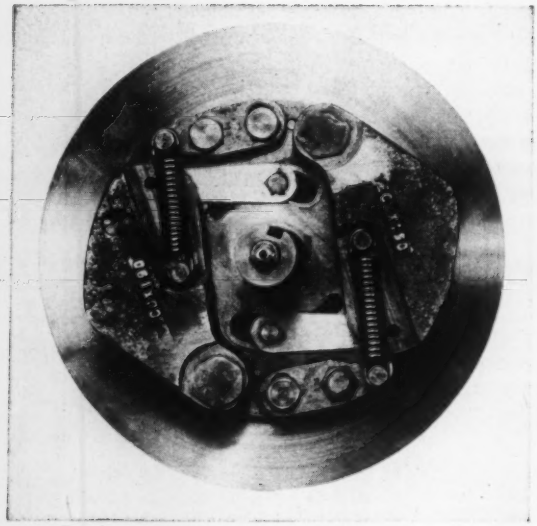
To extend a double-extension design from fully retracted position, rotating power is applied to the large tube. Containing an integral ball-bearing nut at one end, the large tube rotates about the two smaller concentric screw units, both of which are held stationary until the larger unit is fully extended. At that point the larger screw locks up with the outer tube-nut assembly by means of an internal stop on the ball nut and an external stop on the screw. Then, the large nut and large screw rotate as a unit about the stationary inner screw until the multi-extending assembly is fully extended.

FOAM-PLASTIC AIR DUCTS offer effective method of heat control in electronic assemblies. The construction technique was developed at Sylvania Electric Products Inc. to provide separate cooling and insulation of the tubes in electronic equipment.

Ambient - temperature air is drawn in at the base of each tube and flows out the top between the glass tube and its metal shield. A single piece of foam plastic with formed holes fits completely down over all of the tube shields and serves as a multiple-inlet exhaust duct. Thermal insulation properties of the foam plastic prevents heat from the individual tubes from affecting the rest of the equipment.

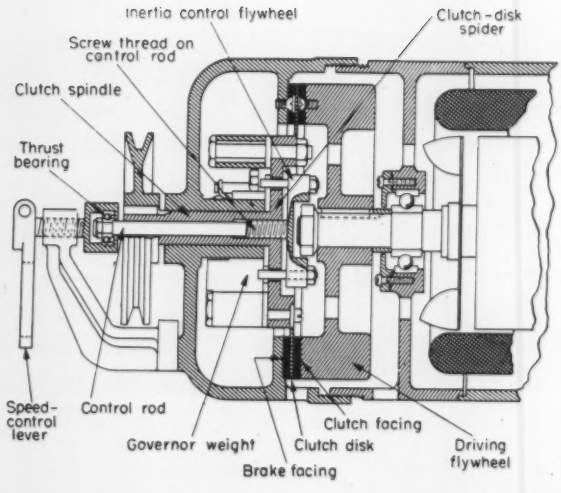


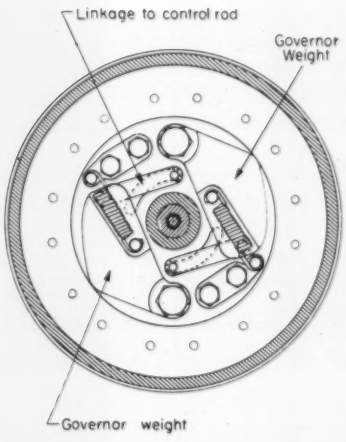


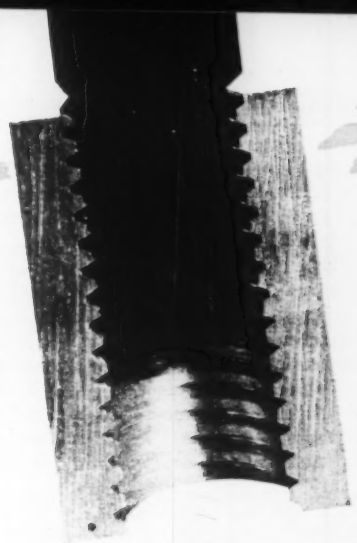


ADJUSTABLE REGULATION of drive speeds over a wide range is offered by an inertia-controlled "flyball' governor system developed by United Shoe Machinery Corp. Applied in mechanical friction transmissions designed for mounting integrally on electric motors, the adjustable governing system provides smooth, regulated output speeds independent of load variations. Output speed is operator adjusted through axial positioning of a control rod, which is threaded at one end to fit into a tapped hole in the clutch-spider hub.

In operation, power is transferred through the transmission whenever the clutch disk is brought into contact with the driving flywheel friction surfaces. As the clutch disk comes up to speed after engagement, the weights on a flyball governor, which is mounted on and rotates with the clutch disk spider, tend to fly outward. Movement of the weights rotates the control rod a few degrees through a connecting linkage, causing the spider and clutch disk to withdraw from the engaged position as a result of screw action between rod and spider. As clutch speed drops, the governor weights move inward, reversing the screw action to reengage the clutch. In operation this process is instantaneously accomplished. Speed change is stabilized by a small inertia flywheel mounted on the end of the control rod. This combination provides a closely regulated output speed. Linear position of the control rod relative to the clutch-disk assembly determines the set-point speed by controlling travel of the weights for clutch disengagement.







New Class 5
Interference-Fit Thread
for studs, bolts and screws

- **What it is**
- **How it developed**
- **How it works**
- **What the future holds**

By William G. Waltermire
Chief Products Engineer
Lamson & Sessions Co.
Cleveland, Ohio

Based on a recently discovered principle of thread action, the tentative standard presented in this article offers new hope to users of interference-fit studs, bolts and screws. Relieved outside diameters permit substantial pitch diameter interference without danger of seizing. Better service performance and lower production cost due to more liberal tolerances are among the possible benefits.

The author, a well-known authority on fastener design who has been actively associated with the development of the new standard, also traces its evolution and relates some of the trials and tribulations of the standardization committee. The story is an interesting example of the behind-the-scenes activity that goes on before a standard is born. The efforts of individuals and organizations in standardization too often go unhonored and unsung, and *Machine Design* welcomes this opportunity to give recognition to those responsible for the new interference-fit screw thread standard.

LITTLE is known of the origin of interference-fit screw threads, generally applied on tap-end studs. But on one point all are agreed: they were troublemakers! This class thread provides a metal-to-metal fit, by flank engagement, of an oversize external thread in a standard tapped hole, resulting in plastic flow of metal. Studs occasionally broke, seized, stripped threads of tapped holes, or backed out. Sometimes they permitted leakage.

Until recently, in this situation, little definite knowledge was available on the effect of lubrication, variation in stud hardness and block hardness, driving practices, length of engagement and a large variety of variables all of which are recognized as affecting performance. The problem was futher complicated by the large variety of forged, cast, diecast, or rolled materials, both ferrous and nonferrous, in which interference fits were used. In fact, as new high-strength and heat-resistant materials were developed, the problem became futher complicated.

Now, fortunately, many if not most of the problems have been solved. The new Class 5 interference-fit screw threads have become workable on studs and, interestingly enough, also on thread-

locking screws and bolts. At the same time they have become less expensive to produce and use.

Studs caused a great deal of difficulty during World War II and concerted efforts were made to eliminate interference-fit studs wherever possible. For example, passenger-car engines largely went from studs to free-fitting cylinder head bolts. This effort was accelerated since studs are, by their nature, more expensive than a bolt or cap screw; this is because it has been next to impossible to hold Class 5 tolerances—completely impossible in the numbered sizes. Furthermore, studs require a nut and involve two assembly operations, whereas only one operation is involved in assembling a cap screw in a tapped hole.

Events proved, however, that studs still are required. This is just as true in missiles, atomic reactors, and other late developments as it is in the older, well-established applications. Studs act as pilots in assembling heavy parts such as cylinder heads to cylinders. The interference fit provides a lock against turning and loosening of the stud both during service and when locknuts are assembled or disassembled. The first is particularly important where maintenance of prestress, to protect against fatigue failure, is required.

Studs provide a metal-to-metal seal which prevents leakage of liquids or fluids through holes tapped in porous materials. Also, the "runout" of a hole and a cap screw or bolt assembled in it is doubled as the screw or bolt is turned during assembly. Clearance holes, therefore, must be sufficiently large to permit this. Also, very little misalignment and mislocation of the holes through which the cap screw is assembled can be permitted. A large part of the runout is believed to be due to hole angularity, which is generally in one direction in a block.

Since driving the stud in a tapped hole is the first operation in assembly, this need for providing large clearance holes and maintaining close alignment of holes is alleviated by the use of studs. Further, it has always been difficult to insure perfect squareness of a tapped hole with its spot face, and of a bolt head with its thread axis. When either or both are not exactly square, the threads of the screw or bolt are overstressed on one side, which reduces their static and fatigue strength. On the other hand, with a stud and nut the adjustment permitted by the flexing action of thread engagement in the nut compensates for these inescapable deviations from perfect squareness in the assembly. On small lightweight units, the use of studs in automatic or semiautomatic machine assembly reduces overall assembly costs since they permit quick and easy "stack-up" of gaskets and different parts of a joint on the assembly line.

These and other advantages account for the continued use of interference-fit studs in spite of their bad reputation as a source of trouble and production line shut-downs.

Engineers, with an eye on service performance, know the need for adequate locking torques. Production-line people, particularly those on piecework, demand speedy assembly conditions and want as little torque as the law allows. Consequently, as engineers continued to put Class 5 limits on drawings considerable "fudging" took place in actual production.

On one tractor engine line, the operator driving studs kept an oversize hand tap in his shirt pocket. If torque started to be excessive he corrected the condition in a hurry, but the resultant hole was outside blueprint limits. On an assembly line for one military vehicle, operators elaborated on this procedure. They tapped all holes oversize, insuring that no stud-hole combination would bind excessively. This meant that most combinations would be a loose free fit, but this was readily corrected. A small blacksmith's anvil was located at the assembly station and the operators were expert at wielding a hammer on the threads of the stud. Again, the resultant fit was not according to drawing design, but it worked—temporarily at least. These and similar practical corrective steps were widespread although generally unknown to the design engineer.

It was the bad performance of the old Class 5 studs coupled with a persistent need for interference fits that gave rise to patented developments like Lok-Thred studs and cap screws. This type has a tapered root which engages the root of a tapped hole in such a manner that the resultant metal flow is always in the hole. While Lok-Thred studs are expensive and require close control of hole minor diameter, they were and are a great improvement over the old Class 5 thread.

The New Class 5 Standard

Several major causes of the trouble with Class 5 threads have been discovered in the last several years. It is now felt that the necessary corrections are known. At the same time as they remove or alleviate the trouble, these corrections should result in better tolerances and reduced production costs of stud and hole, as well as opening up extension of use into the smaller sizes.

Based on these findings, a new standard has been prepared and presented to the Industrial Fasteners Institute as IFI Tentative Class 5. It will, in turn, be presented to the American Standards Association for consideration as a tentative American standard. It is hoped this article will bring understanding of the reasons behind this development and accelerate further needed research and the exchange of information and observations which will result from field experience on a large scale.

This standard is shown in Tables 1, 2, 3 and 4. The dimensional standard, Tables 1, 2 and 3, ap-

plies to the Coarse-thread series in the ¼-in. to 1½ in. size range. If the conditions in Table 4 are violated, parts made to the dimensional limits specified may not work. Suggested instructions for the Fine thread are also included in Table 4.

Elements embodied in the proposed standard and the accomplishment of it, are:

Hole, Table 2.

a. One hole PD, Class 3, is maintained for each size in all materials.

b. Class 3 hole minor diameter (ID) is maintained in all sizes of nonferrous material and for sizes up to ⅜-in. in ferrous materials.

c. The larger hole minor diameter (ID) of the *Screw-Thread Standards for Federal Services* (1950 Supplement) for Class 5 is used for 7/16-in. and larger holes in ferrous materials. This reduces thread engagement to about 50 per cent but, due to flow of material in driving, adequate thread depth results, and the initial reduction helps prevent excessive driving torques.

Stud, Table 1.

a. One stud PD, equal in amount to Class 3, is maintained for each size regardless of the material in which the stud is driven. In conjunction with Par. a under *Hole*, this means that one range of interferences is maintained regardless of material.

b. Torque control for various material combinations is obtained by regulating length of engagement (L_e) and stud major diameter (OD) as well as by varying the hole ID as described in Pars. b and c under *Hole*. Two sets of stud major diameter (OD) limits are incorporated,

Table 1—Stud Dimensions for IFI Tentative Class 5 Standard*

Size	Major Diameter†						Pitch Diameter†		Minor Diameter†
	Driven in ferrous >160 Bhn§ $L_e = 1¼D$		Driven in brass and ferrous ≧160 Bhn‡ $L_e = 1¼D$		Driven in nonferrous except brass** $L_e = 2½D$				
	(Max)	(Min)	(Max)	(Min)	(Max)	(Min)	(Max)	(Min)	(Max)
¼-20	0.2470	0.2408	0.2470	0.2408	0.2470	0.2408	0.2230	0.2204	0.1932
5/16-18	0.3080	0.3020	0.3090	0.3030	0.3090	0.3030	0.2829	0.2799	0.2508
⅜-16	0.3690	0.3626	0.3710	0.3646	0.3710	0.3646	0.3414	0.3382	0.3053
7/16-14	0.4305	0.4233	0.4330	0.4258	0.4330	0.4258	0.3991	0.3955	0.3579
½-13	0.4920	0.4846	0.4950	0.4876	0.4950	0.4876	0.4584	0.4547	0.4140
9/16-12	0.5540	0.5460	0.5580	0.5495	0.5580	0.5495	0.5176	0.5136	0.4695
⅝-11	0.6140	0.6056	0.6195	0.6111	0.6195	0.6111	0.5758	0.5716	0.5233
¾-10	0.7360	0.7270	0.7440	0.7350	0.7440	0.7350	0.6955	0.6910	0.6378
⅞-9	0.8600	0.8502	0.8685	0.8587	0.8685	0.8587	0.8144	0.8095	0.7503
1-8	0.9835	0.9727	0.9935	0.9827	0.9935	0.9827	0.9316	0.9262	0.8594
1⅛-7	1.1070	1.0952	1.1180	1.1062	1.1180	1.1062	1.0465	1.0406	0.9640
1¼-7	1.234	1.220	1.2430	1.2312	1.2430	1.2312	1.1715	1.1656	1.0890
1⅜-6	1.356	1.341	1.3680	1.3538	1.3680	1.3538	1.2839	1.2768	1.1877
1½-6	1.481	1.467	1.4930	1.4788	1.4930	1.4788	1.4089	1.4018	1.3127

*Studs are steel ASTM A-325 (SAE Grade 5 or better).
†All dimensions are in inches, for rolled, cut or ground threads.
§In ordering, add OD limits in the D x L description. Thus "⅛-13 (OD 0.4920/0.4846) x 2½ in. IFI Class 5 tap end stud type—."
‡In ordering, it is not necessary to specify the OD. Thus D x L description automatically calls out the stud OD limits.
**In ordering, it is not necessary to specify the OD. Thus D x L x T x N description automatically calls out the stud OD limits.

Table 2—Hole Dimensions for IFI Tentative Class 5 Standard

Size	Ferrous Material			Nonferrous Material			Virtual Diam (Pitch Diam)		Major Diam
	Minor Diam (Min)	Minor Diam (Max)	Tap Drill	Minor Diam (Min)	Minor Diam (Max)	Tap Drill	(Min)	(Max)	(Min)
¼-20	0.1959	0.2060	13/64	0.1959	0.2060	13/64	0.2175	0.2201	0.2500
5/16-18	0.2524	0.2630	G	0.2524	0.2630	G	0.2764	0.2794	0.3125
⅜-16	0.3073	0.3184	O	0.3073	0.3184	O	0.3344	0.3376	0.3750
7/16-14	0.3736	0.3813	⅜	0.3602	0.3721	U	0.3911	0.3947	0.4375
½-13	0.4313	0.4396	7/16	0.4167	0.4290	27/64	0.4500	0.4537	0.5000
9/16-12	0.4882	0.4972	12.5mm	0.4723	0.4850	31/64	0.5084	0.5124	0.5625
⅝-11	0.5444	0.5542	35/64	0.5266	0.5397	17/32	0.5660	0.5702	0.6250
¾-10	0.6614	0.6722	43/64	0.6417	0.6553	16.5mm	0.6850	0.6895	0.7500
⅞-9	0.7768	0.7888	49/64	0.7547	0.7689	49/64	0.8028	0.8077	0.8750
1-8	0.8901	0.9036	57/64	0.8647	0.8795	⅞	0.9188	0.9242	1.0000
1⅛-7	1.0152	1.0322	1	0.9704	0.9858	63/64	1.0322	1.0382	1.1250
1¼-7	1.1248	1.1402	1⅛	1.0954	1.1108	1 7/64	1.1572	1.1631	1.2500
1⅜-6	1.2286	1.2466	1 13/64	1.1946	1.2126	1 13/64	1.2667	1.2738	1.3750
1½-6	1.3536	1.3716	1 39/64	1.3196	1.3376	1 21/64	1.3917	1.3988	1.5000

All dimensions are in inches, unless otherwise specified.

Table 3—Interferences and Engagement Lengths for IFI Tentative Class 5 Standard

Size	Interferences on Pitch Diam (Max)	Interferences on Pitch Diam (Min)	Engagement Lengths, Stud Thread Lengths and Tapped Hole Depths — In brass and ferrous — L_e*	T_s†	T_h min‡	In nonferrous except brass — L_e*	T_s†	T_h min‡
¼-20	0.0055	0.0003	5/16	3/8 −.000 +.125	3/8	5/8	11/16 −.000 +.125	11/16
5/16-18	0.0065	0.0005	23/64	15/32 −.000 +.140	15/32	23/32	51/64 −.000 +.140	49/64
3/8-16	0.0070	0.0006	13/32	9/16 −.000 +.156	9/16	13/16	1 1/32 −.000 +.156	1 1/32
7/16-14	0.0080	0.0008	31/64	21/32 −.000 +.180	21/32	1 3/32	1 13/64 −.000 +.180	1 13/64
½-13	0.0084	0.0010	5/8	3/4 −.000 +.191	3/4	1¼	1 3/8 −.000 +.191	1 3/8
9/16-12	0.0092	0.0012	37/64	27/32 −.000 +.210	27/32	1 11/32	1 55/64 −.000 +.210	1 53/64
5/8-11	0.0098	0.0014	33/64	15/16 −.000 +.225	15/16	1 9/16	1 33/64 −.000 +.225	1 33/64
¾-10	0.0105	0.0015	19/32	1 1/8 −.000 +.250	1 1/8	1 7/8	2 1/16 −.000 +.250	2 1/16
7/8-9	0.0116	0.0018	1 3/32	1 5/16 −.000 +.276	1 5/16	2 5/16	2 13/32 −.000 +.276	2 13/32
1-8	0.0128	0.0020	1¼	1½ −.000 +.315	1½	2½	2¾ −.000 +.315	2¾
1 1/8-7	0.0143	0.0025	1 13/32	1 11/16 −.000 +.359	1 11/16	2 13/16	3 3/32 −.000 +.359	3 3/32
1¼-7	0.0143	0.0025	1 5/16	1 7/8 −.000 +.359	1 7/8	3 1/8	3 7/16 −.000 +.359	3 7/16
1 3/8-6	0.0172	0.0030	1 33/64	2 1/16 −.000 +.420	2 1/16	3 7/16	3 33/64 −.000 +.420	3 33/64
1½-6	0.0172	0.0030	1 7/8	2¼ −.000 +.420	2¼	3¾	4 1/8 −.000 +.420	4 1/8

All dimensions are in inches.
*L_e=Length of engagement, †T_s=Stud thread length, ‡T_h=Depth of tapped holes.

one for very hard material and the other for the remainder. Both limits provide an OD tolerance of about two times Class 3 PD tolerance:

1. For majority of driving, that is, in brass and in ferrous material under 160 Bhn, the length of engagement is $1\frac{1}{4}D$ and the minimum stud OD limit is set about equal to the minimum for Class 2A. In ordering, unless OD limits different from these are included in the stud description, it is considered that these stud OD limits are intended in the term "IFI Class 5 Thread" in the description.
2. For driving in ferrous materials of 160 Bhn and harder, the length of engagement is also $1\frac{1}{4}D$, but stud OD's are reduced further as indicated in Table 1. In ordering studs of this type, stud OD limits shall be included in the description.
3. The same stud OD as that used for brass and ferrous material under 160 Bhn, Par. b1, is used for driving in nonferrous material other than brass, but with a $2\frac{1}{2}D$ length of engagement. This last provides a needed increase in torques for these nonferrous materials. Note that the IFI description for ordering any studs with a tap-end thread length different from $1\frac{1}{2}D$ specifies that description be $D \times L \times T \times N$. No attention need be called to OD limits since it is automatically required by the use of the term "IFI Class 5 Thread."

Thread Lengths, Table 3.

Stud thread lengths and hole depths for length of engagement, $L_e = 1\frac{1}{4}D$, are set at $1\frac{1}{2}D$ (-0, $+ 2\frac{1}{2}$ pitches). This is a reduction of length from the old standards and thus results in speeding up drilling, tapping and driving. For $L_e = 2\frac{1}{2}D$, stud thread length and hole depth are similarly set at $2\frac{3}{4}D$.

As will be detailed later, in order to promote understanding of the standard, these dimensional limits and design and driving practice recommendations resulted from pilot research in Coarse-thread stud functioning, much of it basic. It was originally hoped that a relieved OD type Class 5 Fine-thread series could also be set up by adapting the Coarse-thread results. It was the thought to

(1) strike a ratio, size for size, of UNF 2A PD tolerance to UNC 2A PD tolerance, then (2) apply this ratio to the new Coarse-thread Class 5 stud PD tolerances, OD tolerances and minimum interferences, and (3) use NF 3 holes. It was decided, however, that this would be too risky with no research and very limited experience using the Fine thread.

Evolution of the New Standard

This new standard results from action started about 1947 when ASA (American Standards Association) Sectional Committee B1 on Screw Threads, sponsored by the American Society of Mechanical Engineers and the Society of Automotive Engineers, created Subcommittee 10 to explore the subject of interference fits and develop a workable standard. The late Mr. Harry Marchant of the Chrysler Corp. was appointed Chairman and promptly, as a starter, organized a survey of stud and tapped-hole practices to see if a solution to the trouble could not be found in this manner. Companies such as Allis - Chalmers, Caterpillar Tractor, Chrysler, Oldsmobile, Pontiac, Cadillac, GM Truck & Coach, Cleveland Diesel, Allison, Buick and many others co-operated. They reported, for many sizes and thread pitches, stud OD, PD and root diameter limits, hole PD and hole ID limits. The resulting chart for one size is shown in Fig. 1. They also reported tapping practice, lubricants and lubricating practice, driving practice and about every element which could conceivably affect functioning.

The results strongly indicated that everyone was in trouble and that no one had the answer. As a result, a Research Subgroup was formed on June 10, 1949. The charge to it read, "development of basic thread dimensions for roll-threaded and pointed studs of approximate 1020 steel, unheat-treated (bright), in commercial cast iron, using a length of engagement of 1¼ diameters. Holes to be tapped with PG-1 limit taps, stud PD's to vary in increments of approximately 0.001-in."

The Subgroup was further charged with investigating the effects of performance of various lubricants, platings, and surface treatments on studs, and finally to recommend tolerances on the stud and hole. The late Mr. Stephen Chayke, a Ford Motor Company tool engineer, was asked to chairman this group.

Upon the death of Mr. Marchant, the author became Chairman of Subcommittee 10 and joined the Research Subgroup in an exofficio capacity. This brought the working members of the Subgroup to include Messrs. Leo Salmi, research engineer, Ford Motor Co.; Charles Wright, standards engineer and R. L. Jackson, metallurgist, Chrysler Corp.; Mr. Chayke and the author. Later on the group was joined, as occasion demanded, by Mr. W. R. Campbell, physicist, and Mr. Irvin H. Fullmer, chief of the engineering metrology section of the National Bureau of Standards. Mr. Campbell had been associated in the original Bureau of Standards research which resulted in the existing Class 5 standard. Both contributed vitally to analyzing and interpreting the work of the Committee.

It is a pleasure to give credit here to those who made the work of the foregoing group possible, to the men of the Ford and Chrysler plants who tapped and checked the test blocks, to Anton Spuhler and his men of Lamson & Sessions who made endless lots of studs, varying one thing at a time, and to those of Bethlehem Steel and Pittsburgh Screw & Bolt, who made 7/16-in. studs at the outset but which, because of developments,

Table 4—General Design Notes for IFI Tentative Class 5 Standard

Lubrication

For driving in ferrous material, a good lubricant-sealer must be used, particularly in the hole. A non-carbonizing type lubricant is suggested. No lubricant is normally necessary for driving in nonferrous material.

Holes

In inspection of tapped holes, plain plug and thread plug gages should be run to full depth. This will detect undue wear of drills or taps near their starting end.

If holes are burred, they should be lightly countersunk to facilitate starting the studs.

Studs

Use of pitch micrometers, circular wires or other means of measuring actual PD of studs is recommended. Do not use ring gages. (Circular wires permit measurements of stud PD after driving and removal as well as before driving.)

Studs should be pointed below basic hole diameter as required by the Industrial Fasteners Institute Standard for tap-end studs.

In ordering studs for use in ferrous materials of hardnesses greater than 160 Bhn, the stud OD (major diameter) limits must be included in the stud description when ordering. On other studs, this specification is not necessary.

Stud Materials

The length of engagement, depth of thread engagement and pitch diameter in Tables 1, 2 and 3 are designed to produce adequate torque conditions when heat-treated medium-carbon steel studs, ASTM A-325 (SAE Grade 5) or better, are used. In many applications, case-carburized studs or unheat-treated medium-carbon steel studs are satisfactory.

This tentative standard is not intended to cover the use of studs of stainless steel, Duronze, brass or similar. When such materials are used, the dimensions listed herein will probably have to be adjusted by pilot experimental work with the actual combination of materials involved.

Smaller Sizes

Contrary to past experience, stud sizes can be extended downward. However, adequate data are not now (1956) available to permit setting a standard.

Fine Pitch

Use of the Coarse-thread series is urged unless requirements of stud strength make a finer pitch necessary. No research data are available now (1956) to enable the setting of a tentative standard for Fine-thread studs having reduced major diameters. Indications, however, are that application of the ratio

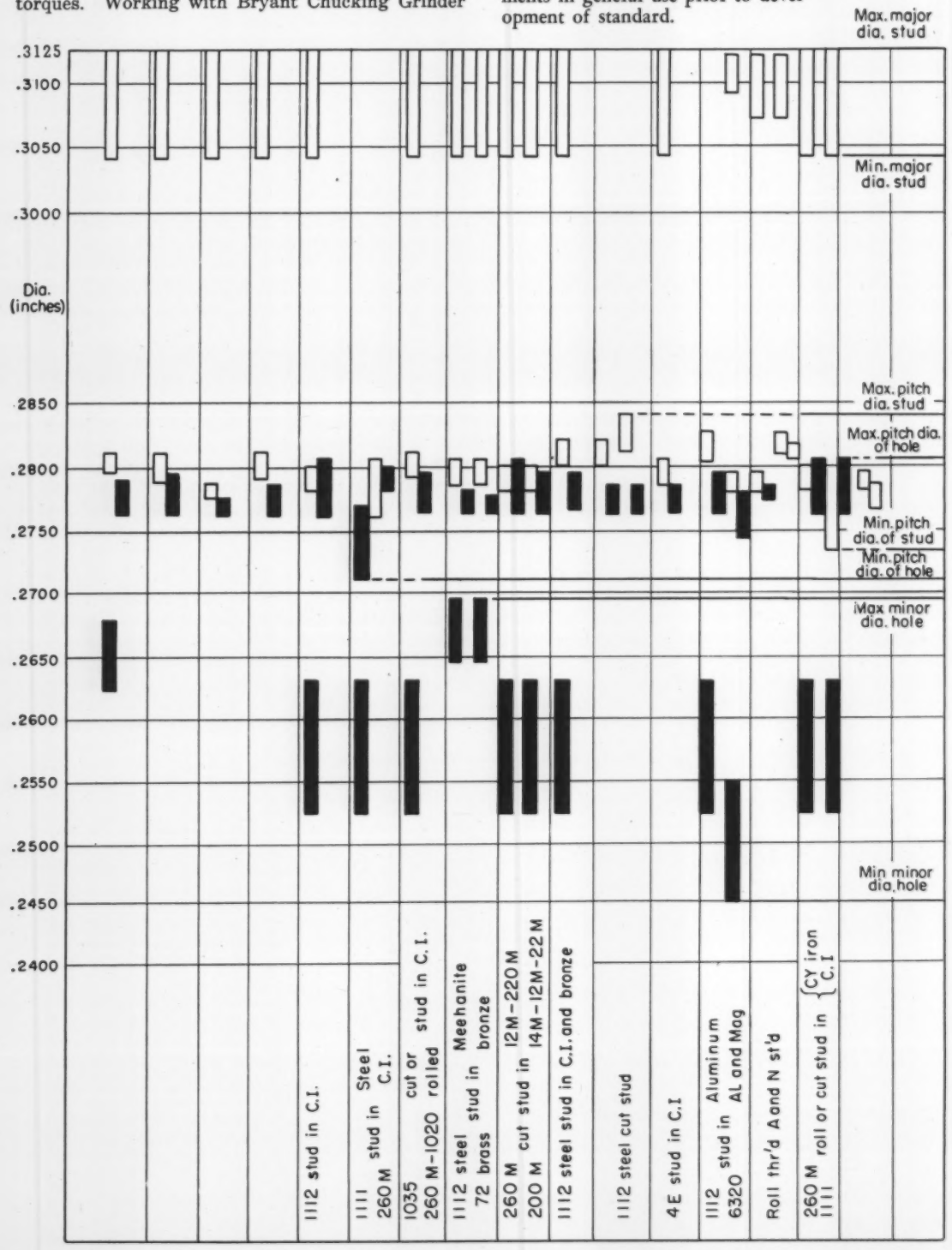
$$\frac{\text{Class 2A UNF PD tolerance}}{\text{Class 2A UNC PD tolerance}}$$

to the following Coarse-threaded stud characteristics will work: (a) stud OD tolerance, (b) stud PD tolerance, (c) minimum interference.

were never tested. As this work was done at a time of production overloads it required, at times, actual sacrificial effort on their part.

Ford Motor Co. developed a machine, Fig. 2, utilizing SR-4 gages and a strain analyzer and recorder to accurately drive and measure stud torques. Working with Bryant Chucking Grinder Co., they secured a segmented type indicator gage which permitted measurements of hole pitch diameters before and after driving. Stud pitch diameters were measured with an O-VEE circular wire type gage.

Fig. 1 — Limiting dimensions of 5/16-18 stud and hole thread elements in general use prior to development of standard.



All costs were borne by the three companies, each of whom paid entirely for the material, labor and services each one contributed.

Test results in July and August of 1951 were so erratic that it was decided holes had to be tapped on a lead-screw tapper and extra special care taken to eliminate lead, drunkenness and taper from stud threads. Holes and studs were produced accordingly and, as later events showed, the special precautions for the tapped holes and studs were found to be largely unnecessary as the trouble lay elsewhere, although at that time it was not realized.

In January, 1952, testing was resumed and it was quickly learned that it was necessary to lubri-

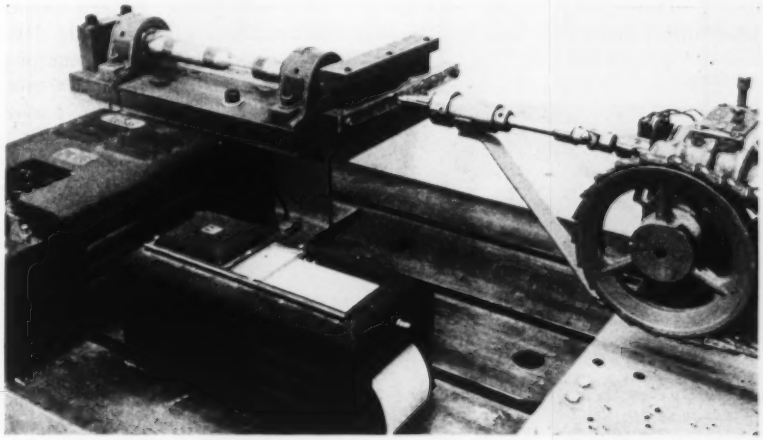
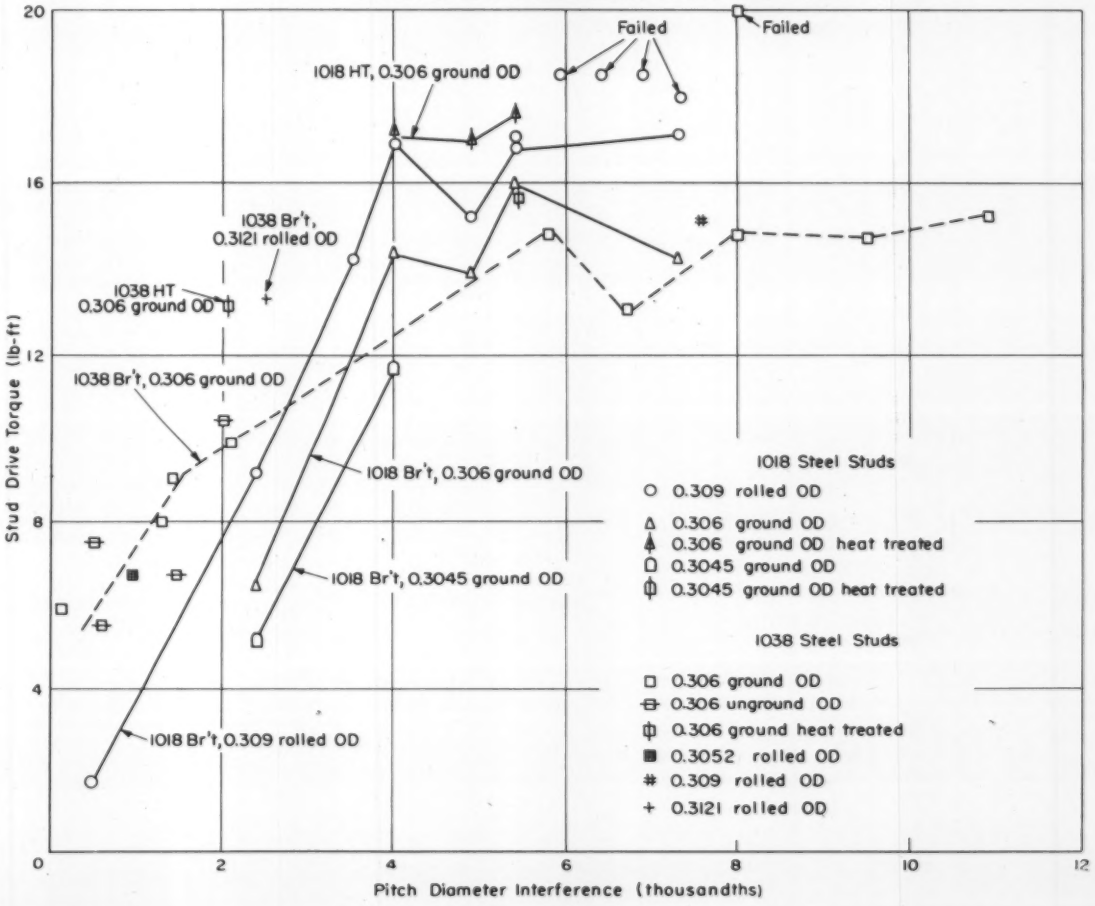


Fig. 2 — Torque-recording test machine for stud driving, developed by Ford Motor Co. Titan driver is rotated about 33 rpm by motor through speed reducer, right, and contains adjustable spring-loaded over-riding clutch to limit maximum driving torque. Torque reaction on test-bar is transmitted through dynamometer shaft which is anchored at upper left. SR-4 strain gages attached to the necked portion of the shaft permit recording the torque on Brush Strain Analyzer and Recorder, foreground.

Fig. 3—Below—How stud drive torque is affected by pitch diameter interference. Note leveling-off at high interferance values. Scatter is partly due to lead error and drunkenness in individual studs.



cate the hole to drive studs in the Ford Grade "A" Cast Iron, 109 to 120 Bhn. The lubricant was Ford M5398-A, a ground rubber-in-water dispersion which is a sealant as well as a noncarbonizing lubricant.

It is significant that driving torque was erratic when only the stud was lubricated. But when only the hole was lubricated, torque was about the same as when both stud and hole were lubricated. Driven dry, studs were broken at measured interferences as low as 0.0005-in., but with the hole lubricated, it was possible to test to the limit of the stud torsional strength.

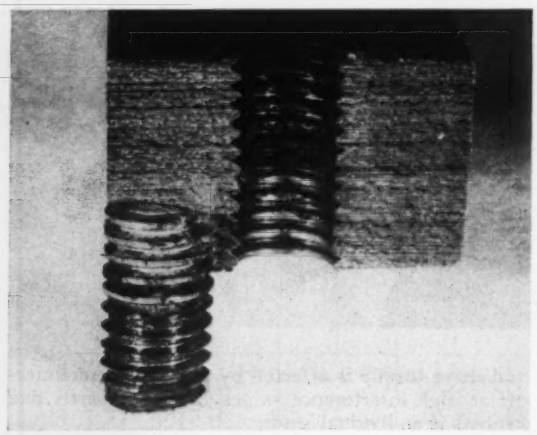
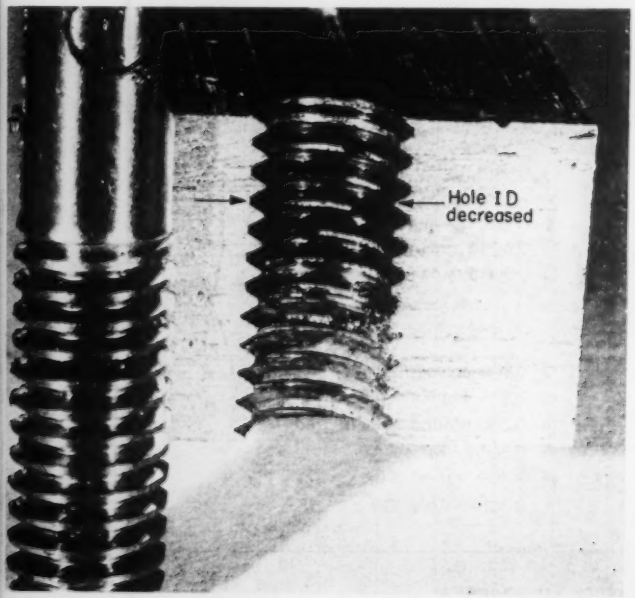


Fig. 4—Cutaway of tapped hole in hard cast iron, 269 Bhn, after assembly and removal of 1038 unheat-treated stud. Stud failed due to material weakness. Growth of stud OD is clearly indicated by sharpness of thread crests near stud point.

Fig. 5—Cutaway of tapped hole in aluminum block after assembly and removal of stud. Here the stud squeezed the material from the hole threads inward, sharpening the crests and decreasing the hole minor diameter. In other cases the pressure may distort the material around the hole, causing enlargement.



The action of lubricating the hole can best be compared with a man sliding down a hill on the seat of his breeches. Lubricating the hill provides less friction than lubricating his posterior. The comparison is obvious.

With this discovery, tests proceeded, but still the torques seemed inconsistent with PD interference and sometimes at medium PD interferences seizing would develop. When driving was stopped at the instant of seizing and the test blocks were sectioned, it was noticed that the seizing or tearing action always started at the OD of the stud on the threads near the point. It was also observed that the stud OD's grew in driving although the cast iron plates were considerably softer than the stud material.

Experiments with reducing the stud OD disclosed, for the first time, that torques seemed to be associated with PD interference even when holes varied considerably and studs had considerable lead and helix angle variation in differing amounts.

Further tests convinced us we had made a basic discovery: *Interference due to the growth of stud thread OD in driving had been the main cause of the seizing which blocked the tests initially.*

Several other important findings and conclusions were tentatively obtained from the research, but this one—OD growth and its effect—was the most important one of all. All past research and stud experience had indicated that high PD interference could not be permitted, but had ignored the effect of OD growth. By reducing PD interference, it is true, trouble was alleviated since less metal was moved. This new discovery opened the door to larger interferences and more realistic tolerances.

From then on research was conducted with reduced OD studs; soon it was found that the low torsional strength of 1018 studs made 1038 studs more desirable, particularly since the two materials exhibited about the same flow characteristics. In Fig. 3, PD interferences are plotted along the abscissa and the resultant torques along the ordinate. As the chart indicates, 1038 studs, 5/16-18, were driven at PD interferences as high as 0.0109-in. with only one failure which occurred at 0.008-in. when removal of the locknut was attempted after loading to 14 lb-ft. This failure was due not to seizing and galling, but to weak material in the stud, which was unheat-treated.

The important findings of this phase of driving in cast iron, particularly as they guided further research and development, were as follows:

1. Holes must be lubricated.
2. Stud OD's must be relieved so that, after being driven, they will not approach nominal stud size and cause seizing.
3. When holes are lubricated and stud OD's relieved, torques increase with PD interference to a certain point and then level off. Beyond this point, further increase of PD does not seem to appreciably increase torque, Fig. 3. This proved true for both 1018 and 1038 studs.

4. Driving and redriving studs established that, in cast iron, most of the initial torque is retained on subsequent drivings. It was concluded that only a small portion of the driving torque is absorbed by the plastic flow, or movement, of the cast iron. Perhaps this is the reason torques do not increase with interferences at higher amounts of interference. Most of the driving torque is probably absorbed in elastic action between stud and hole material.
5. Torques increase directly with the number of turns in engagement.
6. Driving to a predetermined length of engagement is recommended. Both *shouldering* (driving on the stud thread runout) or *bottoming* (tapping shallow and driving until stud bottoms) invite torsional failure as stud movement is suddenly stopped. There are other bad effects, particularly the setting up of radial compressive stresses. These probably contribute to reduced fatigue strength and to out-of-roundness of cylinder walls, etc. In a 1952 report, a German group had already concluded that "under conditions of heavy axial load on the studs the annular stresses are soon lost."
7. It was decided that, in cast iron, a length of thread engagement of 1 to 1½ diameters is adequate.
8. Minimum torque, it was concluded, should be at least 50 per cent more than the torque required to break loose a nut loaded in assembly so that, when the nut is removed, the stud will not turn. It is a fallacy to consider that a stud must only resist the free torque of a locknut.
9. Gaging the full depth of both the drilled holes and the tapped holes is important. Drills and taps wear first at the point and this, it was concluded, contributes to erratic and excessive torques.
10. All threads were rolled but, for research, many of the OD's were ground. However, experiments showed that the natural OD resulting from the rolling operation reacts the same as a ground OD.

The first phase of the program was completed when the foregoing report was made to Subcommittee 10 with the recommendation that further research be undertaken on cut, rolled and ground threads, in different sizes, of different stud materials, and driven in different tapped hole materials.

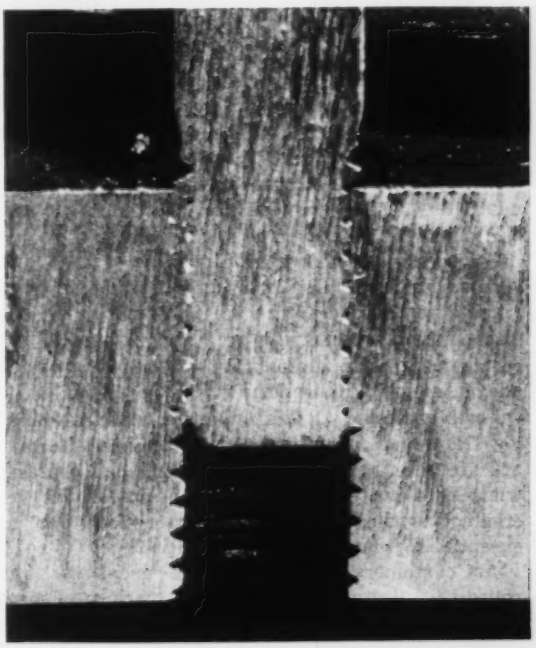
As the Shakeproof Div. of Illinois Tool Works volunteered to pay the cost of labor involved in any research placed at the Armour Research Foundation, Illinois Institute of Technology, Subcommittee 10 directed the Subgroup to develop a program of test, obtain a bid from Armour and submit it to the sponsor, the American Society of Mechanical Engineers.

In the meantime it was decided to continue unofficially as a Ford-Chrysler-Lamson & Sessions group and complete those tests just ready to start. Tests were made with C-1038 unheat-treated 5/16-18 studs and C-1038 5/16-18 studs quenched and tempered to SAE Grade 5 physical properties. They were driven to $1\frac{1}{4}D$ length of engagement in the following materials: (a) Chrysler hard cast iron, 269 Bhn; (b) aluminum alloy, 86 Bhn; and (c) magnesium alloy, 65 Bhn. With SAE Grade 5 studs in the hard cast iron, no stud breakage was obtained until interferences of 0.0086-in. or higher were used, Fig. 4, and even then one stud drove satisfactorily at 0.0092-in. interference. The OD of the stud increased above nominal and it was felt that a greater OD relief on the stud, in this hard cast-iron material, would have reduced torques. These were much higher interferences, of course, than those needed to provide comfortable working tolerances for stud and hole and still maintain a decent minimum interference in the loosest condition.

For the sake of comparison with performance in cast iron, studs were driven to $1\frac{1}{4}D$ length of engagement in the aluminum and magnesium, although it was realized that a greater length of engagement would be needed. The fact that torques increase directly with number of turns engagement in a straight-line relationship made it probable that torques at engagements greater than $1\frac{1}{4}D$ could be predicted.

There seemed to be little or no difference whether the holes in aluminum and magnesium were or were not lubricated and, therefore, most of the studs were driven dry in these materials. Close look at an aluminum cutaway, Fig. 5, indicated that the crest of the threads near the top of the hole "sharpened up" as the stud drove. The same characteristics were observed in a cutaway of a magnesium plate. Insofar as torsional strength was concerned, the studs for use in aluminum or mag-

Fig. 6—Cutaway of cap screw assembled in alloy steel block. Here the block material squeezed the material from the stud threads outward, increasing the stud OD, especially near the point of the screw. With insufficient OD clearance this can cause seizing.



nesium need not have been heat-treated as the highest torques were: in aluminum, 16 lb-ft at 0.0086-in. interference; in magnesium, 15.5 lb-ft at 0.0077-in. interference. This is well under the minimum torsional strength of C-1038 unheat-treated 5/16-18 studs.

In both aluminum and magnesium, measurements indicated a surprising fact. Both the hole PD and the hole ID were *less* after a stud was driven and removed than they were before. Visual inspection showed that this would be true of the ID, but the explanation and acceptance of the PD measurements were more elusive. This had been observed by the author and others, however, in other applications such as pipe plugs driven in holes tapped in aluminum and zinc-base die castings that were not too ductile. Later events proved the observations to be sound.

With this information, a modest program was developed, a quotation obtained from Armour and submitted to ASME. After considerable deliberation, ASME advised that neither they nor the co-sponsor, SAE, felt justified in putting up money to complete the research as the subject was not one of enough general interest.

This development is reported only to answer those who may question why more research was not conducted. The fact is that the sponsors' stand was coupled with a growing demand for a Class 5 standard from the ASME-sponsored ASA Sectional Committee B1, born of real need, and this made a solution necessary while the means to do it were cut off. This should not be interpreted as a reflection on ASME or SAE. The situation arose from the fact that it is unusual for a Standards committee to operate a research group and therefore the mechanics to do this was not there. Research is normally a separate activity which precedes any standardization effort.

The pilot research then completed showed very clearly that it would be impossible to set up a decent standard without further research. Yet, without the means, the situation for a time was at an impasse.

In time, further problems arising from production and usage, field experience and observations and, finally, a decision to continue alone with catch-as-catch-can Lamson & Sessions research, resulted in sufficient information to prepare the new IFI Class 5 thread standard.

Research and Field Experience

It was necessary to find out the reaction to the idea of large interferences on the part of the people who buy and use studs, particularly where there may be no control of the tapped hole. Accordingly, studs were prepared and tests conducted for several days at the plant of a leading automotive engine rebuilder in the middlewest. Engine rebuilders must accept the holes in cylinder blocks as they come; after the wearing and loosening of studs in service and the cleaning of cylinder blocks, the spread of hole sizes is abnormal. Here, it seemed, the idea of large-interference relieved-OD studs should find an exacting proving ground.

Studs 7/16-in. in diameter were driven in Dodge and Plymouth blocks at measured interferences from 0.0023-in. to 0.0123-in. Holes measured from 0.0008-in. under minimum to 0.0037-in. over maximum for Class 3, showing the effect of wear and cleaning. SAE Grade 5 studs were used.

No seizing, breakage or difficulty of any kind was encountered. Use of larger PD studs did eliminate stud looseness in badly oversize holes. It also enabled driving to a stop and eliminated the requirement that studs be shouldered to develop adequate holding torques.

Tests indicated that shouldering studs, even at low PD interferences, seemed to contribute to out-of-roundness of cylinder walls; on the contrary, when studs were driven to a stop, no tendency to create out-of-roundness could be found even at exceptionally large PD interferences.

As customers experienced the usual cut and rolled-thread stud difficulties in a variety of sizes in armor plate, rolled steel, cast iron, die castings, alloy-steel forgings and other materials, and in both coarse and fine threads, lessons tentatively learned from cut-and-try methods were slowly applied. In this period, a painfully relearned lesson was that in very hard material, stud OD's will grow more than normally in driving and, therefore, have to be relieved a greater amount than with softer materials.

It was also found that interference fits below the size limitation of ¼-in., heretofore considered the smallest practicable one, could be successfully applied. Since, formerly, a ¼-in. Class 5 thread only permitted 0.007-in. tolerance on stud PD, 0.0008-in. on hole PD, and still only maintained a minimum interference of 0.0003-in., it is readily seen why even the ¼-in. size was impracticable. In fact, the PD tolerances, particularly on the hole, were impossible.

In view of the insistent need for a standard, Lamson & Sessions finally decided to go ahead with their own test program and make maximum and minimum relieved OD threads, rolling them on SAE Grade 5 hex-head cap screws. Cap screw heads were used as the hex head facilitates driving. It was also desired to demonstrate the value of the thread in producing a trouble-free reusable thread-locking cap screw or bolt.

Test plates of seven different materials were prepared, representing general material usage. Screws were driven in all the plates and the results of driving plotted.

One hole in each plate was reserved for driving tests which were later conducted on March 19, 1956, in the presence of the Stud subcommittee of

the Industrial Fasteners Institute for confirmation of tests already made and recorded. The members of the subcommittee present on that day, who favorably recommended establishment of the IFI Class 5 standard were: Albert McLeod, Erie Bolt & Nut Co.; William Povey, Pawtucket Screw Co.; Robert Riley, Bethlehem Steel Corp.; Andrew Robertson, Pittsburgh Screw & Bolt; together with guests Irvin Fullmer of the Bureau of Standards and W. C. Stewart and Richard Belford of the Industrial Fasteners Institute.

All driving, in both nonferrous and ferrous materials, was conducted at 1 to $1\frac{1}{4}D$ length of engagement. Screws were driven dry in brass and aluminum and lubricated in all the others with the ground rubber-in-water lubricant-sealant. Most driving was by hand to permit torque measurements. Based on past experience and contrary to the common belief, the author is confident that trouble-free performance would also have resulted had the screws been power-driven.

For the purposes of this phase of research, regardless of size or material, hole PD limits were Class 3 and stud PD limits provided a tolerance equal in amount to Class 3.

Regardless of material, one hole minor diameter (ID) was used for each size, the relieved type in the 1950 Supplement of *Screw-Thread Standards for Federal Services.*

Regardless of material, one stud major diameter was used for each size, that which is now shown in Table 1 for studs driven in brass and ferrous material under 160 Bhn.

In driving, ½-in. holes were checked for PD and ID before and after driving (gage segments were not available for the ¼-in. and ¾-in. hole PD's); studs also were checked for PD and OD before and after. In assembling, the length the stud could be inserted before the start of thread engagement was measured and recorded and a longitudinal mark made on the stud and plate at this point. Torques were then read at each turn from this mark. Studs were rolled commercially. Holes were tapped commercially with ground taps.

Observations on the foregoing tests were:

1. Driving increased the OD of studs as follows:

Block Material	OD Increase for Screw Size (in.)		
	¼	½	¾
Ferrous, 250 Bhn and over	.003	.010	.018
Ferrous, 160-250 Bhn	.003	.008	.010
Ferrous, under 160 Bhn	.003	.005	.006
Nonferrous	.001	.001	.002

The ½-in. cutaway of Fig. 6 shows visually how the OD increases, particularly on the threads nearest the point. This indicates the amount stud OD's have to be reduced before driving so that OD will not increase beyond nominal, causing excessive torque—and seizing and galling in driving. Note that the increase is greater with diameter, as well as with hardness of block material.

2. Measuring hole ID and PD, before and after driving, presents quite a problem—compared to the relatively easy task of measuring stud OD and PD before and after. Added to this is the elastic reaction of the hole material. After an oversize PD stud is driven in a hole, the hole PD must almost certainly increase. When the stud is removed and the hole is measured, however, both the ID and PD of the hole may be found to decrease in certain materials. This fact, that the hole PD and ID tend to be less after driving and removing the stud than before the stud was driven, seems to be particularly true of certain elastic grades of nonferrous material, but it must also be said that sometimes measurements indicate the reverse, regardless of materials.
3. Stud breakloose torques proved to be very close to stud drive torque regardless of material.
4. As PD interferences increase, torques increase to a given level and then drop or level off, as indicated by the graphs of test results, Fig. 7.
5. Torques increase with length of engagement. The increase was relatively rapid on the ¾-in. size, all materials, and relatively slow on the ¼-in. size, all materials. The increase for the ½-in. size was in between. This was indicated by graph plots of the test results, Fig. 7. On these figures the delta (Δ) symbol is used to indicate the amount of interference and all three sizes, ¼, ½ and ¾-in., are plotted on each graph. In considering the graphs, it is interesting to note that the torsional strength of these SAE Grade 5 studs in lb-ft is as follows:

Stud Size	Torsional Strength (lb-ft) Calculated Minimum	Actual
¼-20	9½	14
½-13	100	135
¾-10	325	440

These calculated values were derived by determining a theoretical radius for the threaded area of the stud, working backward from the tabulated values for mean stress area. Torsional strength was then calculated using the derived radii and assuming that unit shear stress is 60 per cent of the minimum SAE Grade 5 tensile stress of 120,000 psi. Since the ¼ and ¾-in. studs are close to the minimum SAE Grade 5 hardness of 23 Rockwell C, it is obvious that the calculated torques are too conservative. The actual values were found by clamping the bolts in a vise, using splice nuts to hold the threads of the ¼ and ½-in. sizes; the ¾-in. size was driven in a blind tapped hole. In developing the dimensional limits of Table 1, the foregoing torsional strengths were considered in taking corrective steps to raise or lower the torques in the standard based on torque test results plotted in Fig. 7.

6. Torques increase with depth of thread engagement. This results from the combination of stud OD and hole ID.
7. It was interesting to note that the variations in tapped hole PD from six holes in each ½-in. plate were as follows:

Plate Material	Hardness	Variation
Alloy Steel	269 Bhn	.0020-in.
Meehanite	197	.0018
Grey Cast Iron	126	.0025
Rolled Steel Plate	116	.0036
SAE 660, Bronze	95	.0005
Comm. 319 Aluminum	129	.0035

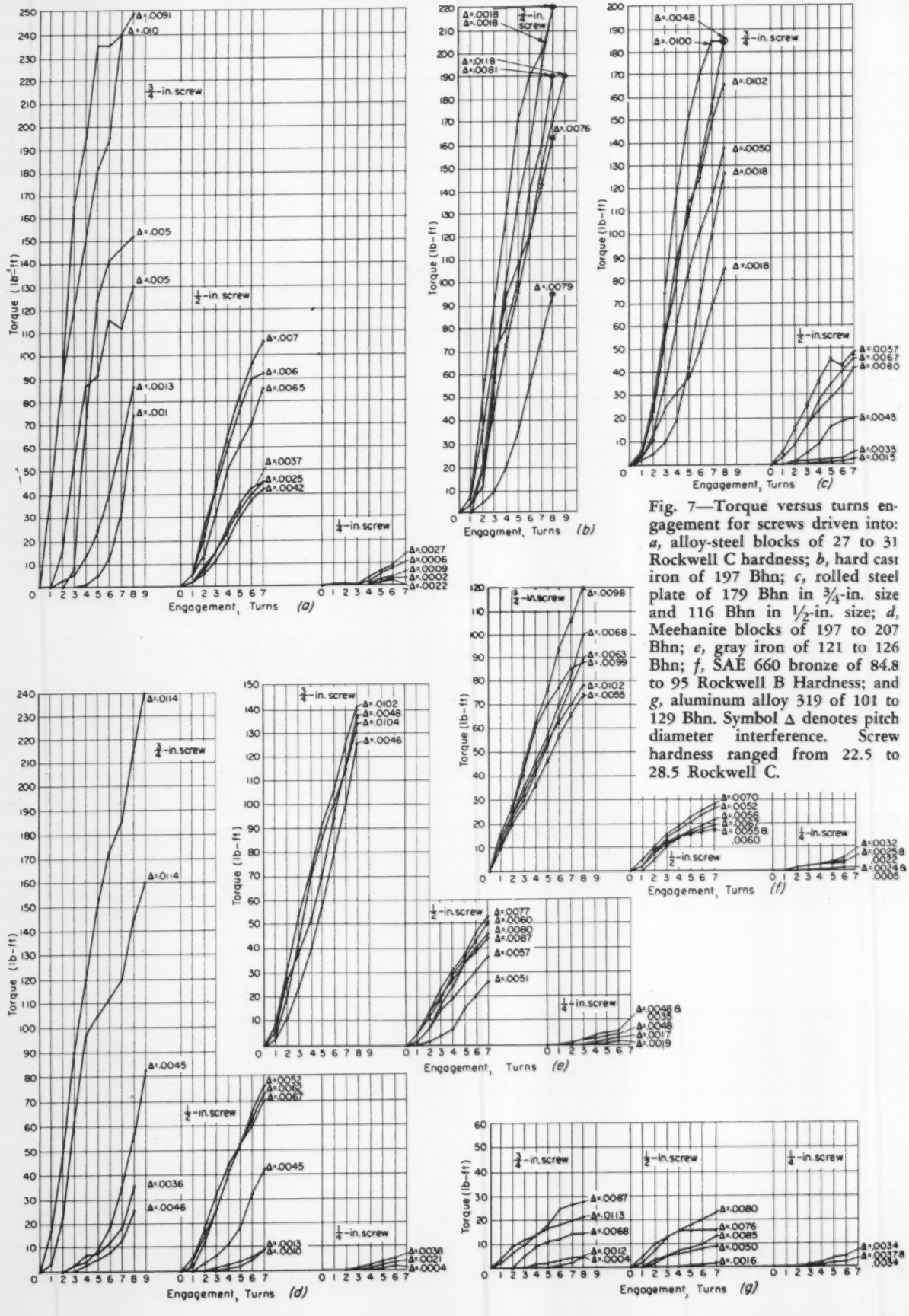


Fig. 7—Torque versus turns engagement for screws driven into: *a*, alloy-steel blocks of 27 to 31 Rockwell C hardness; *b*, hard cast iron of 197 Bhn; *c*, rolled steel plate of 179 Bhn in ¾-in. size and 116 Bhn in ½-in. size; *d*, Meehanite blocks of 197 to 207 Bhn; *e*, gray iron of 121 to 126 Bhn; *f*, SAE 660 bronze of 84.8 to 95 Rockwell B Hardness; and *g*, aluminum alloy 319 of 101 to 129 Bhn. Symbol Δ denotes pitch diameter interference. Screw hardness ranged from 22.5 to 28.5 Rockwell C.

It is admitted that these holes were not produced on lead-screw tappers and that the tap was not the optimum one for all materials. Nevertheless, (1) studs worked in these holes, variations and all, and (2) conditions and variations such as these are often obtained in practice. These results indicate why a standard predicated on maintaining low PD interferences is unrealistic.

It will be recalled that on all sizes and in all materials, the hole ID had been relieved and the stud OD moderately relieved. The results of the research clearly indicated the following trends and corrective measures to produce torque characteristics about the same as those listed in the 1950 Supplement to *Screw-Thread Standards for Federal Services*:

1. By and large, this combination of relieved stud OD and hole ID works well. In fact, in no case was there any seizing or breaking of studs on the one hand, or loosening of studs on the other.
2. On the ¼-in. size, torques were rather low, regardless of material as shown in Fig. 7. For this reason, the new standard, Table 2, uses a Class 3 hole ID up to and including the ⅜-in. size, eliminating the relieved ID hole in this group. The size break was selected arbitrarily, based on previous experience and observations.
3. Torques were particularly low for all sizes in aluminum. The standard therefore recommends an increase in length of engagement from $1\frac{1}{4}D$ to $2\frac{1}{2}D$.
4. On materials 179 Bhn and harder, torques on the ¾-in. studs were unnecessarily high from the standpoint of speed and cost of assembly. This confirmed the painful experience the author previously had at a large automotive plant. The new standard of Table 1, therefore, sets up added OD truncation for studs driven in ferrous materials harder than 160 Bhn. Again, the hardness break was arbitrarily set, based on general observation and experience, and should be adjusted if mass-production experience later proves it desirable. The amount of truncation chosen is less arbitrary, however. It is not quite as much as one experience, with a ⅝-in. stud driven in a drop-forged alloy-steel shaft of about 290 Bhn, would indicate as being required. The author believes, however, that the amount in the standard is adequate as other elements were present in the case mentioned.

In reporting this research and progress, little mention has been made of the importance and effect of variations from perfect lead and angle of stud and hole, commonly and incorrectly designated as lead error and angle error.

The author is tempted to conclude that, with this relieved OD type stud thread, commercial variations in lead are not important enough to warrant the specification of a limit and consequent inspection control. However, an experience with hardened alloy studs, used in alloy-steel cylinder blocks by a truck manufacturer, makes this conclusion questionable. This manufacturer runs all his engines five hours to break them in, and then disassembles and cleans them out completely before final reassembly and installation. He found that those studs having a lead variable larger than 0.002-in. per in. would develop excellent torque characteristics on assembly, but tended to back out during disassembly of the engine. Therefore, in critical applications it may prove desirable to tolerance lead, and possibly angle variables.

As for lubricants, many types are successfully used. Probably any one with a good body, preferably one that will not carbonize with age or heat, is good. Some lubricants do harden in service, making it impossible to remove a stud without breakage if, as happens, removal becomes necessary due to bent studs, stripped threads or other causes. A lubricant should also provide a seal, closing off any openings in the helixes along the thread OD and the thread root.

In this research, the ground rubber-in-water dispersion was used because it had been used by Ford Motor Co. since about 1949 and its performance in service had been demonstrated. To get comparative results from this research, however, it seemed desirable to stay with one lubricant as there already were a number of variables, both known and unknown which made interpretation difficult.

The all-important thing is to lubricate the hole. The *Aeronautical Recommended Practice*, ARP 142A (SAE) controls lubricants as follows:

> Lubricants, when assembling studs, should be used with care. Anti-seize compound composed of Petrolatum and Graphite on a 240 base viscosity lubricating oil, or a compound composed of lead soap base grease and mineral oil, may be used. The lubricant may be applied to the hole or the stud. It is preferred that the lubricant be applied to the hole; however, extreme care should be used so that an excess amount of lubricant will not cause the stud to hydraulic in a blind hole. Use only sufficient lubricant to cover the sides of the threads with a thin layer.

Comments on both the subject of lubricants and that of extending Class 5 thread limits to sizes smaller than ¼-in. are well expressed in the following extract of a recent letter received from a manufacturer of guided missiles:

> Our immediate problem relative to a permanent assembled 8-32 stud in a die casting had to be resolved rather hurriedly . . . For your information, we used a number 28 (0.1405) tap drill with a Class 3 tap of 0.1456 pitch diameter. Four sizes of studs were made with pitch diameters 0.1457 to 0.1488 inclusive, increasing by approximately 0.001 steps. The three largest studs produced satisfactory results, driving with a torque of from 15 to 24 lb-in. To obviate galling, a lute consisting of white lead and oil of heavy paste consistency was used in driving. From this we obtained a minimum interference of 0.0036 on the pitch diameter with a maximum of 0.0051. Our immediate problem seems resolved; however, the important one is to establish a standard for sizes 6, 8, 10 and ¼-in. in steel, wrought aluminum alloys and die castings. It is obvious that in steel the interference would be considerably less. Whether the interference on both wrought aluminum and die castings is identical I cannot say at this moment.

Future Developments

The foregoing experience shows the need for further research and suggests the direction. Past experience in aluminum-base die castings strongly suggests that some of them develop torques, for any given interference, generally similar to those of brass or common steel, but that the hole ID and the hole PD both close in more than those in wrought aluminum. Aluminum die castings are generally among the several "rubbery" materials which produce excellent stud-locking torques both on the first and on subsequent applications, but create a sealing problem. If the latter is a factor, a sealant must be used.

With guideposts generally established, research into the numbered sizes, using reduced OD studs or cap screws, should not be unduly difficult, expensive or time-consuming. By mid-summer, 1956, it is hoped and expected that Subcommittee 10 of ASA Sectional Committee B1 will have taken the first steps. In the meantime, users of individual sizes can be generally guided by the lessons learned on the larger sizes.

The problems of manufacture and inspection of roll-threaded or of ground-thread studs are greatly eased by the proposed standard as it provides ample tolerance on both thread major diameter (OD) and pitch diameter (PD). In fact, since the maximum PD as well as the minimum PD is an actual pitch diameter, and may be measured by pitch micrometers or indicators, the entire difference between the maximum and minimum limits is available as tolerance for manufacture.

A comparison of the old ½-13 limit against the new indicates the increased tolerances permitted by the new Class 5 thread:

	Old	New
Stud PD	0.0029	0.0037
Hole PD	0.0019	0.0037

On smaller sizes, the gain is greater.

For a given blank diameter, it is significant that as the PD is increased in the process of roll-threading a blank, the OD is automatically decreased. This is exactly what has been done in designing the new Class 5 thread. Pitch diameters have been increased while major diameter limits have been decreased. Thus, the action taken to perfect driving characteristics happily coincides with the natural flow of metal in production.

On cut-thread studs, this gain in PD tolerance is somewhat offset by the need for reducing the major diameter at the tap end as this formerly was established by the bar-stock size. The new standard still eases the cut-threading problem, however.

It is anticipated that the new Class 5 thread will receive general acceptance and application on studs and, increasingly, on screws and bolts since it provides a positive thread-locking action at relatively low cost. The possibilities with screws are particularly intriguing since they can be used in a tapped hole, eliminating a nut, or a locking screw can be used with a common nut, replacing the need for a locknut. The fact remains, of course, that the more expensive studs present certain design and assembled-cost advantages of their own under certain conditions.

In considering the extension of the IFI Class 5 thread to screws or bolts, the question of reusability comes to the fore. It is the author's considered opinion that this new Class 5 thread can be removed and reapplied as many times, and retain as much locking power, as any other type thread which develops its locking power by moving metal. Nevertheless, there are several outstanding facts which should be considered in deciding whether the IFI Class 5 thread has adequate reusability to be applied to a screw or bolt:

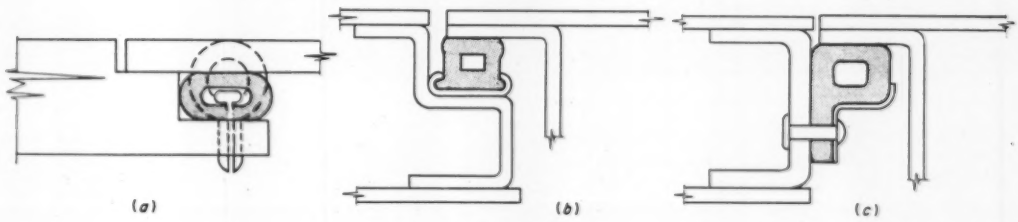
1. Most materials have considerable springiness and develop high reusability as this article reported earlier in connection with the Ford-Chrysler-Lamson & Sessions tests in cast iron.
2. Some materials, apparently in the minority, do not. Confusion arises from the fact that, for example, one aluminum die-casting material develops exceptionally good reusability characteristics, while another develops very little. The line does not seem to be necessarily between the general kinds of materials, but also between the different types or grades of a given kind. Much remains to be learned on this.
3. While studs are primarily designed to stay put, screws must be capable of being reused.
4. Since studs are driven to a stop, on reapplications the stud may be driven a little further each time, generally only a quarter turn or so, to regain torque lost on reapplications. However, unless a washer is used under the head of the screw on the first application and removed on subsequent applications, this could not be done with a screw.

In spite of these questions, or warning notes, the author is optimistic about the future of Class 5 threads on screws and bolts. For one thing, most materials do seem to provide good reusability characteristics. For another, the manner in which the Lok-Thred has been accepted on cap screws is an indication as to how the IFI Class 5 thread can be accepted.

Improving strength, eliminating trouble and reducing cost constitute the record of achievement written daily by design engineering; this is the objective toward which all those who have brought this stud research to its present state are aiming. The compelling pressure of need and circumstances forced the expense and action so far, but confined it to a few individuals and companies. In fact, it meant diversion of effort and energy from normal product development activities.

With this article, and with publication of the standard, it is hoped that participation will broaden, that popular opinion will back more formal research and that this and a wider collection of experience, unselfishly pooled, using reduced OD Class 5 threads will speed up solution to the problems and accelerate knowledge of stud thread action and the means to control it in a growing list of materials.

Fig. 1—Types of non-pressurized door seals: *a*, tubular seal with trimount fasteners; *b*, bulb extrusion with formed channel; *c*, P-section with back-up strip.



Design details and rubber compounds for large-area low-pressure

CLOSURE SEALS

By Russell W. Beckim, *Production Design Engineer*
Northrop Aircraft, Inc., Hawthorne, Calif.

CLOSURE seals are used for two primary purposes: to prevent the flow of air, water, or other fluids and to maintain pressure in a pressurized space. This article discusses the types and applications of closure seals and the kinds of rubber compounds that may be used in their construction. Closure seals treated here have wide application, but the particular examples cited and the basis of experience for the article are drawn from the aircraft industry.

Types of Seals

Depending on their structure, shape, or operation, the general types of seals are bulb, flap, sponge, pneumatic and diaphragm. Nonpressurized seals rely upon the resiliency of the rubber compound to obtain sealing action. This type is usually a bulb or tubular extrusion, Fig. 1. It is intended to prevent the passage of air at low pressure differentials, usually 3 psi or less, and to prevent the entrance of water. The simplest form is a tube fastened in place by mechanical snap fasteners. Other extruded shapes such as "P" and square seals employ the same basic hollow section but differ in the method of attachment. All the bulb seals are simple to manufacture and install. They have good mechanical strength and the surface is not easily damaged. However, they require high closing loads.

Tube and Bulb Seals depend on design applications for their sealing qualities. In some instances it may be difficult to achieve the desired seal due to tolerance build-up of the seal and the components between which it is used. As an example, a tube seal has a tendency to collapse due to the curing process.

Straight lengths of tubing should have an ovality tolerance which on small sizes is usually ± 10 per cent of the diameter. The ovality is defined as the difference in the major and minor axes of the cross section expressed as a percentage of the nominal diameter. Since a tube that collapses in one direction expands in another, a 10 per cent ovality will be equivalent to 5 per cent variation from the nominal diameter. On a tube of 0.50-in. nominal diameter the tolerance is ± 0.02-in. in accordance with Aeronautical Material Specifications. The same specifications allow an ovality of ± 10 per cent which would permit a diametrical variation of 5 per cent or ± 0.025-in. Since the ovality tolerance is larger than the diametrical tolerance, the latter can be ignored as included

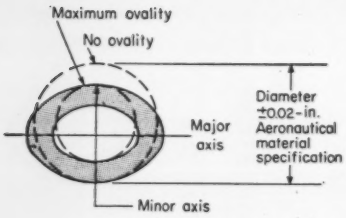


Fig. 2—Tubular seal dimensions.

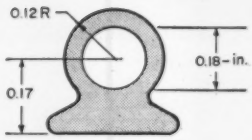


Fig. 3 — Insufficient dimensioning. Figure requires overall dimension to avoid tolerance build-up.

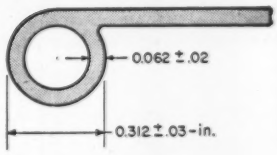


Fig. 4—Unnecessarily large tolerances.

in the ovality. The final seal dimension is established as 0.50 ±.025-in.

In general, tube and bulb seals are designed for a maximum compression of 20 per cent. For design, therefore, nominal compression should be 10 per cent. The dimension 0.50 ±.025-in. allows a seal variation of 0.475 to 0.525-in. Designing for 10 per cent compression of the seal gives a nominal gap dimension of 0.45-in. Applying the sheet metal tolerances of ±0.04-in., used by many aircraft companies, to both a door and frame, gives a gap that can vary from 0.37 to 0.53-in. This gives a seal compression that might vary from 30 per cent to no seal at all. However, a smaller range of compression can easily be obtained by reducing the tolerances on mating components. If the metal tolerances were set at ±0.01-in., the gap would then be 0.45 ±.02-in. or 0.43 to 0.47-in. With the same seal, this would give a compression of 10 to 18 per cent, Fig. 2.

No overall dimension is given for the bulb seal in Fig. 3. It is therefore necessary to compute the height by the addition of partial dimensions. Assuming that the tolerance of ±0.02-in. applies to all dimensions, the values 0.17 ±.02-in. plus 0.12 ±.02-in. give a total of 0.29 ±.04-in. This is a large tolerance on such a small seal.

If the seal and gap dimensions were worked out as in the previous example, they would produce the same error of excessive compression at one extreme and no seal at the other. Reducing the tolerances on the gap will not be sufficient to guarantee a satisfactory seal in this case. It will be necessary to reduce the tolerance on the seal to ±0.01-in. and that of the metal parts to ±0.005-in. and, since 20 per cent compression is maximum, the design should specify 10 per cent compression. Perhaps a more satisfactory method of achieving an adequate seal with this design is to increase the overall dimension of the seal to 0.40 ±.02-in. This would allow a gap of 0.36 ±.01-in.

The bulb seal in Fig. 4 has a seal diameter of 0.312 ±.03-in. This large tolerance is unnecessary and leads to serious design problems, especially when applied to small seals. To achieve an adequate seal here with a 20 per cent maximum compression, it is necessary to reduce the seal tolerance to ±0.02-in. and design for a gap of 0.28 ±.01-in.

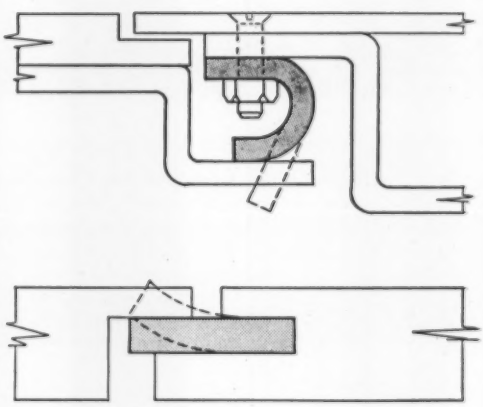


Fig. 5—Types of flap seals.

Flap Seals utilize a thin, solid section of rubber to effect sealing. The advantages of these inexpensive seals are ease of manufacture and installation, and low closing pressures. However, flap seals present tolerance difficulties and are more susceptible to mechanical damage than bulb seals. Flap seals should not be used to seal pressurized areas because of the danger of the flap turning over and resulting in a sudden loss of pressure, Fig. 5.

Sponge Seals are used for weather sealing and are not recommended for pressurized compartments. They are very satisfactory for inspection plates, access doors and other small sheet-metal covers.

The sponge seal is easy to install, usually by cementing, and has the ability to seal over irregularities. It is however subject to compression set.

Sponge seals are usually designed for a maxi-

mum compression of 20 per cent of the seal thickness. They require much lighter loads to produce this amount of compression than is needed to produce an adequate seal with solid sealing materials. When open cell sponge is used, the surface should be treated to prevent the absorption of water or other liquids. Closed cell sponge will not require treating, but it expands slightly at high altitudes due to the pressure of gas within the cells. The height of sponge seals should be less than two-thirds of the width to avoid bending or rolling.

Diaphragm Seals are illustrated in Fig. 6. Seal *a* is an extrusion similar to a bulb seal except that the diaphragm seal is wider. Seal *b* is formed by cementing suitable rubber sheet around an aluminum extrusion. The assembly is held to the door by screws and nut plates. Seal *c* is formed from a rubber extrusion and a special aluminum shape. Seal *a* should be used only in pressurized compartments, and seals *b* and *c* may be used in either pressurized or nonpressurized areas.

Seals utilizing a diaphragm of rubber and a thin depressor have been applied to sealing doors on aircraft. This type of seal has several advantages over the common bulb type. The sealing action is more positive due to the large deflections that may be applied to the diaphragm and closing loads are lower. The rubber will have little compression set, and any pressure differential may be utilized to make a better seal. Disadvantages of the diaphragm seal are the complex installation procedure and the large areas of rubber exposed to possible damage. Protection can be provided to minimize damage, however.

The diaphragm seal was originally intended for sealing pressurized chambers, and is still one of the best seals for this purpose. It may also be applied to nonpressurized doors with good results.

Pneumatic Seals are used where closures must be made after mating surfaces are in place. A seal of this type was used on the canopy of a Northrop airplane. A bulb or diaphragm type seal would soon be torn by the canopy sliding over it. The pneumatic seal is retracted into its channel and is thus protected from damage. A pneumatic seal can be used to seal a variable gap and the leakage rate can be controlled by adjusting the internal seal pressure. It is, however, an expensive seal to manufacture. Damage by puncture causes loss of all sealing properties and repair is so difficult that replacement is usually necessary. The pneumatic seal requires compressed air and the added weight of the compressed air equipment may be sufficient to rule out this type of seal, Fig. 7.

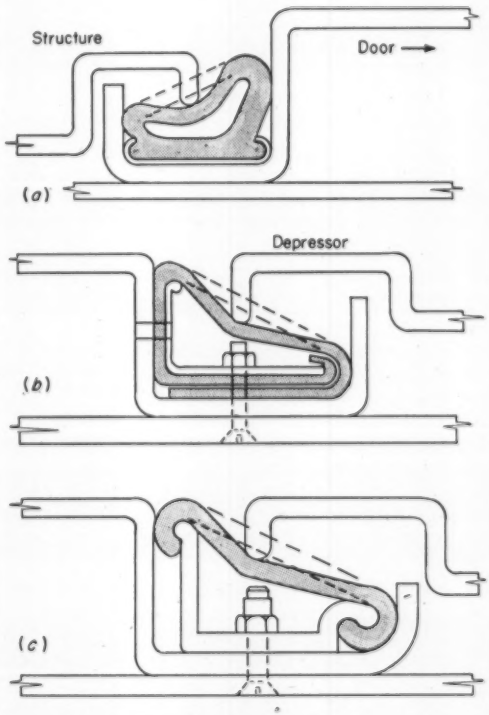


Fig. 6—Types of diaphragm seals: *a*, an extrusion similar to a bulb seal; *b*, sheet rubber formed around a metal extrusion; *c*, a rubber extrusion combined with a special metal shape.

Design Factors

From a comparison of the advantages and disadvantages, the type of seal best suited to the application can be chosen. A consideration of en-

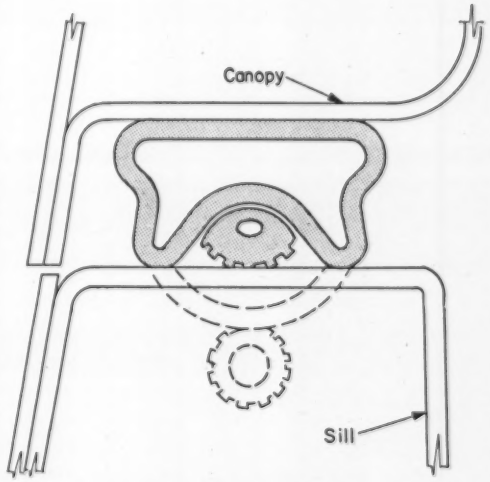


Fig. 7—Aircraft canopy pneumatic seal.

vironmental conditions will determine the type of material to be used. Due to the diverse nature of the environmental factors, the choice of material will necessarily be a compromise.

Properties desired in sealing materials are the following:

1. Weather resistance
2. Tensile strength
3. Tear strength
4. Abrasion resistance
5. Fuel and oil resistance
6. Heat stability and cold flexibility
7. Suitable hardness and compression set characteristics

Since no compound excels in all of these properties, the designer must decide which are the most important to his application and select his compound accordingly. Table 1 gives certain limitations of typical rubber compounds and additional information appears in MACHINE DESIGN, April 19, 1956, Page 128.

The amount of allowable deflection will be determined by the type of seal. Tubular and sponge seals should be designed for a maximum deflection of 20 per cent of the depth of the seal. Diaphragm seals may be deflected 0.125 to 0.375-in., depending on the width of the seal. Greater deflections will cause failure due to cracking or excessive compression set.

Table 1—Pros and Cons of Typical Rubber Compounds

Design Feature	Rubber Stock	Limitations
Low temperature flexibility (—65F)	Silicone rubber (AMS 3301-3305)	Low tensile and tear strength
	Natural	Poor weather resistance and oil resistance (Partially aided by coating seal during original manufacture.)
	Buna-N (AMS 3205)	Poor weather resistance
	FR Neoprene (AMS 3205)	Poor weather resistance
Fuel resistance	Buna-N (AMS 3212-3215)	Poor weather resistance
Fuel resistance ±65F flexibility	Buna-N (AMS 3212-3215)	Poor weather resistance and high swell in fuel immersion with high shrink on drying
High resilience such as shock mounts	Natural (Special compound)	Poor weather and oil resistance
High resilience and weather resistance	Neoprene (Special compound)	Sacrifice some on resilience and service life; also increased low-temperature stiffness to gain weather resistance
Weather resistance	Silicone (AMS 3301-3305)	Low tensile and tear resistance. Low compression set and tendency to creep. Low fuel resistance.
	Neoprene (AMS 3207-3242)	Stiffness at low temperature. High swell from petroleum base hydraulic oil and aromatic fuel.

The method of attachment should be such that the seal is easy to install and easy to replace in service. Cement may be used to attach gasket seals and to set hollow seals in position but mechanical methods of attachment should be used on extruded or formed shapes. The formed channel and back-up strip are recommended. Slow draw-up type fasteners such as screws and Rivnuts are most suitable for use with back-up strips. Rivets should not be used as they cause excessive deformation of the rubber.

If the placement of the seal is such that it may be damaged, the seal should be protected by a metal flange. In some cases, damage may be avoided by attaching the seal to the door rather than to the structure. A recent development in seal protection is a technique of bonding Teflon tape to the outside of the sealing material. The tape presents a tough abrasion-resistant surface and is especially good where the seal is subjected to a sliding motion.

Joints in seals should be kept to a minimum. In general, joints to be vulcanized should be butt joints and joints to be cemented should be lap joints. Where it is necessary to splice a tubular seal, a short length of thin walled rubber tubing may be inserted and the ends cemented together over it.

Seals should be designed with large radii at all corners, and with a small contact area. The small contact area avoids high door closing loads. A depressor 0.064 to 0.072-in. thick and having rounded edges is recommended for a diaphragm seal. The seal should be wide and deep enough to accommodate both manufacturing tolerances and load deflections. Bulb and diaphragm seal thicknesses should be a minimum of 0.062-in. Thinner sections present manufacturing difficulties and produce a seal that is not sufficiently durable.

ACKNOWLEDGEMENTS

The author acknowledges with appreciation the assistance of Mr. C. M. Miller, materials and process engineer, Northrop Aircraft Inc., and the use of the publication *Survey and Development of Seals for Pressurized Aircraft Doors and Canopies*, by Goodyear Aircraft Corp., Akron, O.

They Say . . .

" . . . today it's more important than ever that an engineer be salesminded. He must be keenly aware of the sales importance of the engineering changes and improvements on which he is working. That also involves a good understanding of merchandising, the purposes of advertising, and of the job of selling, itself. Without that kind of knowledge, and that point of view, an engineer is of far less value to his company and to himself."—W. C. NEWBERG, *president, Dodge Div., Chrysler Corp.*

A PAPER FROM THE
THIRD CONFERENCE ON MECHANISMS

KINEMATIC SYNTHESIS

. . . *what it's all about*

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THE CONCEPT of the word *synthesis* implies the combination of parts to produce a complex whole; it is the opposite of *analysis*. Kinematic synthesis is quite specific. It may be defined as the determination of the type and principal dimensions of the parts necessary to a device that is to convert one specified motion into another. The economic forces calling for greater production—the perpetual challenge facing the engineer—bring the matter of synthesis and the advantages of the implied methodicity into sharp focus.

Synthesis and Design: A true method of synthesis would allow an estimation of conflicting possibilities, predict the best combination of parts, recognize the practical, and be deductive. Presently the design of most mechanisms is carried forward on a purely pragmatic basis. The main ingredients of the process appear to be past experience, prejudice and the examination of compendia of mechanical ingenuities. Thus many things may be left to chance. The philosopher Ludwig Noire, while not concerned with mechanisms, made an appropriate observation — "The empirical consideration of things finds only parts but not the whole."

Systematic procedures, which imply time-saving and all-inclusive procedures, are limited to certain areas of design, and even there are not often employed, the principal reason perhaps being inertia. While we may talk about kinematic synthesis, we are really talking about a hope for the future rather than a great reality of the present. The total process appears to be very complex. However, what is known should be reviewed from time to time to insure the widest possible usage of the current knowledge, with the thought that it will stimulate further activity in the desired direction. We can always hope that ultimately the whole story will be put together, even if today we are struggling with pieces of it.

*Now, French Air Force.

Although opposites, analysis and synthesis cannot be separated, for the methods of one may help define a procedure of the other. Much effort has been expended with good results on analyses showing displacement, velocity and acceleration situations in mechanisms built or projected. Graphical methods have a great appeal, and have been greatly extended by the German school. Algebraic methods, often more laborious than the geometric, frequently have the advantages of greater precision and elegance. Russian developments have been inclined in this direction.

Search for a System: It was in the early part of the nineteenth century that kinematics began its departure from the purely pragmatic approach, and the geometric and mathematical gropings began. There was a search for a system, a system that would tie things together into some sort of logical whole. The fundamental relations proved to be elusive, whence mechanisms were classified

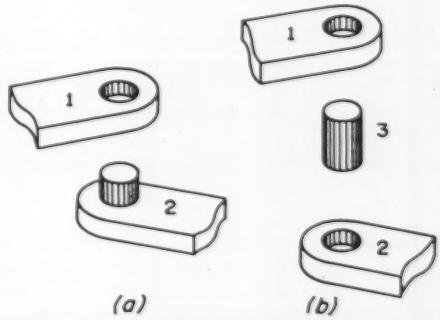

Fig. 1—Pair of elements, *a*, connecting links 1 and 2; *b*, practical equivalent.

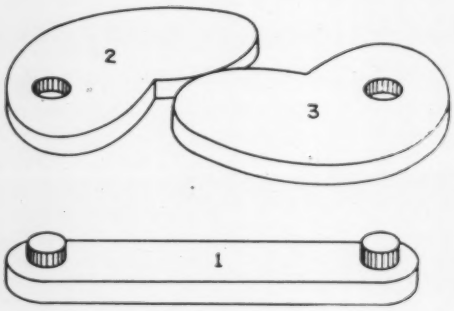

Fig. 2 — Higher pair connection between links 2 and 3; lower pair connections between links 2, 1 and 3.

according to their practical usefulness, as pointed out by Professor Hall in his opening address at the First Conference on Mechanisms (MACHINE DESIGN, Dec. 1953, Page 174-180). Each mechanism was given individual treatment, analytical or geometric, and treated as a separate and unrelated mystery.

Broadly, mechanisms may be classified as either plane or space. In plane mechanisms all the action takes place in the same or parallel planes — the action may be drawn in a single projection. This is not the case for space mechanisms. Aside from the trivial cases employing the screw, perhaps the most common and useful space mechanism is the universal joint (Hooke or Cardan). Many ingenious space mechanisms whose parts are connected by skewed hinges, sliders, ball-and-socket joints and the like have been described. We may think of aircraft landing gear, automobile wheel suspensions, radar scanning antennae, locomotive headlights (Mars), etc.

Except for special applications, space mechanisms are avoided, for the difficulties begin in the design and drafting rooms and continue through the shop. Maintenance may be awkward, and the forces and moments in the device are often such that power transmission (but not motion transformation) may be circumscribed. The employment of space mechanisms in low-power applications, as in computers and control devices, is growing, but the troubles of graphical layouts—following the motions around corners, so to speak—or the cumbersome mathematical analyses, militate against their popular adoption.

Fundamental Concepts: It has been remarked that in the early days it was the motion that was studied and analyzed. Reuleaux reversed this procedure about 1875. He investigated the mechanism —how one part communicated motion to another, or how the connections between parts allowed just a certain kind of relative motion to take place. His studies gave rise to certain concepts that appear to be fundamental. Indeed, most subsequent studies have been based on them. During the course of his investigations he devised a symbolic notation to make possible the description of mechanisms, which would also lead to a method of synthesis. It did furnish a start in one area of synthesis without providing the ultimate answer.

The motions of a mechanism, said Reuleaux, are enforced or constrained because of the connections between adjacent parts. Each connection is made of two *elements,* one element lying on each of the facing parts. In Fig. 1*a* are shown the machine parts or links 1 and 2 connected by a turning pair of elements. On part 1 the interior surface of the circular hole forms one element. The second element is the circular boss of part 2. These two elements constitute the *pair* of the connection. For practical reasons we might wish to use a third part 3, Fig. 1*b*; its use does not change the nature of the relative motion between parts 1 and 2.

If the contacts are made over areas then we speak of *lower pairs:* turning pairs, crossheads, ball-and-socket joints belong to the lower pairs. *Higher pairs* are characterized by line or point contacts between elements: the contact between parts 2 and 3 of Fig. 2 is made by a higher pair.

It is obvious that two or more properly placed elements define a machine part or kinematic *link.* An assemblage of links constitutes a kinematic *chain,* Figs. 3, 5, 6 and 7.

A chain is *closed* when each link is connected to at least two other links, Figs. 5, 6 and 7, and is otherwise an *open* chain, Fig. 3. If each link is connected to two and only two other links, the chain is *simple closed;* if some links are connected to more than two other links, the chain is *compound.* In Fig. 4 link 2 connects to more than two links; again, the connection may be made through the intermediary of a separate part 4 if the bosses of part 2 are removed and replaced by a hole. Two compound chains are shown in Fig. 5; it is apparent that compound chains may be considered as a combination of several coupled simple closed chains.

A chain is *locked, constrained* or *unconstrained.*

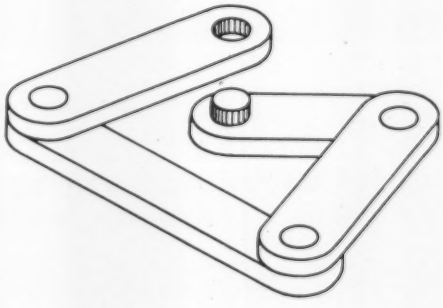

Fig. 3—Open chain.

In a locked chain, as the truss of Fig. 6*a*, no relative motion between links is possible, and the degree of freedom $F = 0$. The structural engineer would call such a chain statically determinate. A chain may even be more than locked, as in Fig. 6*b*, where $F = -1$. This to the structural man is statically indeterminate to the first degree. In what we call the four-bar, Fig. 6*c*, the relative motion between links has a definite and unique character. If one link is held fixed and another moved, the resulting motions of all movable links are determined, and the degree of freedom of the chain is $F = 1$. This is a constrained chain, for a given input is always associated with a unique output. An unconstrained chain is shown in Fig. 6*d*; with five bars, $F = 2$, which means that two inputs are necessary to give a unique motion to an output link. An unconstrained chain has more than one degree of freedom.

In Fig. 7 we finally come to the distinction between chain and mechanism: a *mechanism* is a constrained chain in which one link is held fixed. We also note the *inversion* of a chain—how by fixing different links in succession it is possible to create a variety of mechanisms with widely different output-input relations. It is also recognized that the frame of a mechanism is really a link.

Reuleaux freed us from the bondage of "the five simple machines of the ancients," viz., wheel and axle, lever, pulley, wedge and endless screw. For nearly two thousand years the notion persisted that all machines were constructed from combinations of these five. About 80 years ago Reuleaux presented a classification scheme of six devices from which, by combination, the machines of his day could be built. They were the following:

1. The screw.
2. The crank, i.e., linkwork in the sense of bars —mechanisms with only turning pairs and crossheads.
3. The wheel, including friction and toothed wheels.
4. The tension-compression links—belts, chains, ropes for the first, and hydraulic lines for the second.
5. The cam.
6. The ratchet.

More recently two more have been added by his followers—the hydraulic, as fluid couplings, and the electric.

Types of Synthesis: With these ideas in mind, Reuleaux turned his thoughts to synthesis. He saw two methods, which he called the *direct* and the *indirect synthesis*. The first, direct synthesis, he recognized as hopeless. In dismissing it, he said the following: that it should immediately yield the links and pairs required for a specified motion transformation; that this was out of the question since it was known that the same motion can be obtained in often very different ways; and that no best solution could be hoped for by kinematics alone, since the practical merits of a solution "lie to a considerable extent beyond the sphere of kinematics."

The indirect synthesis held hope, for it is within the province of the method "to give beforehand the solutions of all those problems under which it is possible for the given problem to fall." This is based on the reflection that the number of the kinds of pairs is limited, and that consequently the number of possible combinations is not infinite although great. With limitation, as by using only turning pairs and crossheads, the possible combinations are reduced to reasonable number. This means that all possible combinations can be laid out, looked at and investigated systematically.

We get the feeling that a number of items need detailed consideration. During the course of the years, the overall problem of synthesis has been recognized to consist of three sometimes interrelated phases. It is necessary to decide on (1) the form or type of mechanism, (2) the number of pieces and the manner of their connection needed to give constrained motion, and (3) the proportions of the pieces necessary to accomplish the specified motion transformation.

The first of these is appropriately called *type*

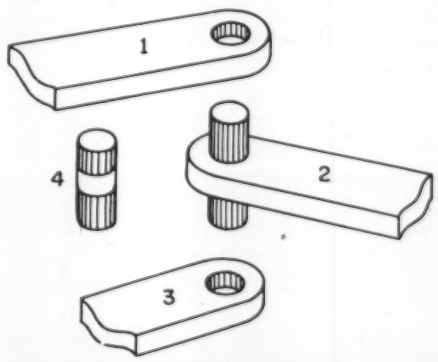

Fig. 4—Compound link (2).

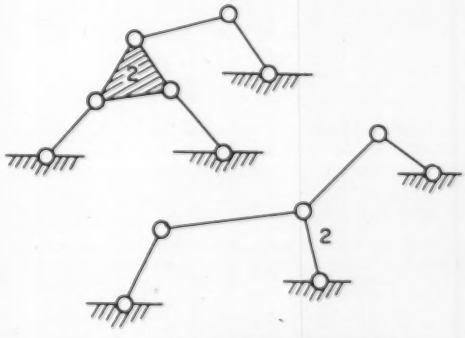

Fig. 5 — Compound chains in which 2 is the compound link.

synthesis—the sort of thing that Reuleaux pioneered. Here the choice of the kind of links or constructional units is determined, as linkwork, gears, cams, belts, etc. Thus, with only turning pairs and simple chains there is the fecund simple-chain family called the four-bar linkage; if a crosshead replaces one turning pair the prolific slider-crank family results. Furthermore, these simple chains can be compounded to give even more complex motions. Many motions possible with linkwork can be derived from cams; it is apparent that a given motion problem can be solved in a variety of ways, depending on the parts. Thus, in the early days of the steam engine, the oscillating motion of the beam was changed into rotary by the use of Watt's sun-and-planet gears as well as the crank and connecting rod. Later, reciprocating motion was changed into rotary by the use of the Scotch yoke or slider-crank. It would be nice to have a scheme whereby a mechanism was uniquely specified on naming a desired motion transformation. As Reuleaux pointed out, this is impossible, and it will be necessary to settle for the next best thing—a line-up of all the possible combinations that could do the job, from which the "best one," considering everything, would be chosen. The ability of being able to establish all possible forms and types that a desired motion-transforming device might take would be of inestimable value in protecting patents, and the labors of patent examiners and patent attorneys would at the very least be systematized.

The second phase is called *number synthesis,* and has to do with the relations of the numbers of links and pairs or joints necessary to produce constrained motion, i.e., a mechanism that is free to just move but not flop. Rules are developed from a consideration of the number of degrees of freedom existing in a joint and lead to the degree of freedom of the chain. These rules are also called criteria of movability. They are expressed in the form of equations, and in this summary we cannot talk about them in detail. One such criterion was given by Gruebler in 1883, and was rediscovered by Walker in 1928, and reported in the *Philosophical Magazine!* It is generally valid for plane simple and compound chains composed of only turning pairs. If some of the turning pairs are replaced by crossheads, the criterion still applies. It must be noted that the criteria fail under some circumstances of geometric configurations. The presence of higher pairs, as cam and follower, or two gears, is handled by substituting an equivalent linkage for the higher pair.

A second criterion, also by Gruebler, but of the date of 1917, relates to space mechanisms, and utilizes only pairs of one degree of freedom. It gives the total degree of freedom of the chain, from which the number of pairs and links compatible with constrained motion may be deduced. For space mechanisms in particular the constraint depends not only on the number of pairs and links but also on their geometry, as the distances and angles between successive elements of the pairs. For example, a simple closed chain of four turning pairs in space is in general locked. However, three special cases are known to be constrained: the plane four-bar linkage; the spherical four-bar, where the axes of the turning pairs intersect at a common point (Hooke's joint is a special case of this special case!); and the Bennett four-bar, where the axes are skewed in accordance with certain special relations.

The third facet is concerned with what the Germans call *Mass-Synthese;* the concept stems from Alt, but is based on Burmester's work. As sometimes happens, there is no English word that will give the full flavor of the word "Mass," which implies measure, geometry, dimension, proportion or size as applied to the lengths of the links. Here we will call it *dimensional synthesis,* although it

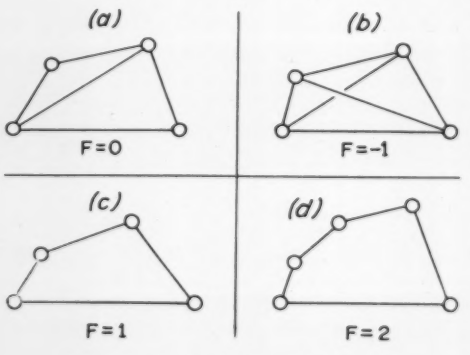

Fig. 6—Locked, constrained and unconstrained chains.

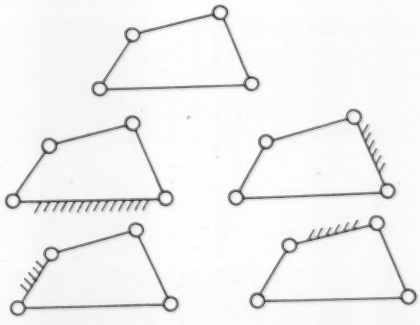

Fig. 7—Four mechanisms created by inversion of chain shown at top.

is also variously called *size* or *geometric synthesis*. At any rate, it is concerned with the determination of the basic geometry of the links—the spacing of the elements—necessary to give a specific motion transformation.

This phase has been subjected to a great deal of study. It is highly complex, for the same problem may involve simultaneous specifications of displacement, velocity and acceleration which are to be fulfilled to certain limits of precision. Thus, it is one thing to ask merely for a transformation of a continuous circular motion into an oscillating motion; this may be done with a certain four-bar linkage. If further restrictions are added, as by specifying certain velocities and accelerations for specific crank angles, the problem departs from the routine. A mechanism may be called for that is to reproduce a certain curve. *Approximate synthesis* (to translate from the German) is the construction of a mechanism that will depart least in its own motion from the prescribed curve. The approximate straight-line motions, such as Watt's, Roberts' and Chebychev's are of this character. Other situations for dimensional synthesis might specify a relation between the angular displacements of output and input in a four-bar, or involve a constrained six-bar with an output dwell after a specified displacement, etc.

Of the two approaches available, the geometric method has been developed by the German school—Gruebler, Burmester, Alt, Beyer—to name but a few. The analytical method has attracted the Russians, Chebychev, Bloch and Dimentberg. Bar linkages of four and more links, as well as the slider-cranks, have yielded most to the blandishments of science.

From this story it appears that synthesis in all aspects is still a mixture of art and science. The designer's skill and judgment still furnish a significant part of the solution while deriving some benefits from the precise and systematic suggestions of the analytical procedures.

Dynamic Effects: It must also be realized that the kinematician's task is no longer restricted to only the purely kinematic aspects of motion as outlined here. To the geometric problem, concerned with only the functional dimensions of the links assumed to be rigid—a static situation, as it were—must be added a consideration of the running characteristics of the mechanism. Decades ago most mechanisms operated at speeds considered low today. The higher speeds with their dynamic effects can no longer be overlooked, or handled by wishful thinking, for they provide inaccurate kinematic performance. Elastic deformations of the "rigid" parts, follower float, tolerances and such things have a new significance, and their recognition may even influence the choice of mechanism type.

European Status: Occasionally a remark is heard to the effect that if the German and Russian literature were directly available all problems would be well in hand. This is decidedly unrealistic, for although the efforts expended and the results achieved in those countries are impressive, a tremendous number of problems still exist. A measure of the serious interest in Russia is given by the fact that a group of specialists in mechanisms and the theory of machines is part of the Academy of Sciences of the USSR. In Germany the Fachgruppe Getriebetechnik (Professional Division for Mechanisms) represents a very active group of the Verein Deutscher Ingenieure.

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industrial design Ideas

who's your boss?

AS a designer, who's your boss? Simple question—simple answer: "the person who buys your products."

How, then, can you satisfy his demands for fair price, high quality, good looks, convenience, etc.? Again a simple answer: "get off your stool and go out to find out." This is a lot different than an occasional tour through your own plant to find out how your brain-children look in metal, yet this is as far as many designers go.

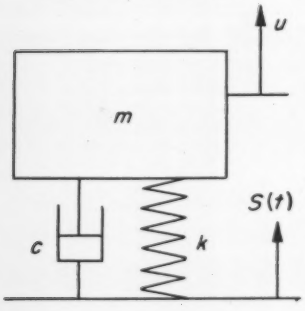
In my years in design, I have jammed my notebook with ideas gleaned from talking to production men, operators, and customers—ideas that were put into final designs. You can do the same, regardless of your products or your markets. If you have a market research department, so much the better, but be sure to use their findings before drawing a single line.

How often I have run into manufacturers who decide they must build a 9⅞-inch hoot-nanny because all their competitors build a 9⅞-inch hoot-nanny—only to find, too late, that a majority of their customers require 10-inch hoot-nannies.

Moral: Use your legs before using your pencil.

—Cliff

Fig. 1—Damped vibrating system with single degree of freedom.



Principles and design uses for

Analog Simulators

Part 2—How to Use the Simulator in Vibration Analysis

By J. N. Macduff,* *Professor of Mechanical Engineering*
Rensselaer Polytechnic Institute, Troy, N. Y.

VIBRATION analyses—in common with dynamic system studies in many design areas—frequently give rise to differential equations of motion. Analog simulators or computers are well adapted to the solution of such equations. In a preceding article,[1] basic components and the elementary mathematics of dc electronic simulators were summarized and applied to the solution of linear and nonlinear equations of the kind encountered in design. In this article, use of the simulator as an engineering tool for studying linearized vibrating systems with one or several degrees of freedom is demonstrated.

The simulator used to obtain the results outlined in this article is on the small side, consisting of ten operational amplifiers and two power supplies. A larger computer, of course, would permit study of vibrating systems with more than three degrees of freedom. Moreover, it would allow examination of the important effects of nonlinearities in the resilient and damping elements.

Solution of differential equations, such as those representing the motion of a damped vibrating body, can be carried out on the analog simulator by either of two methods. First is the *mathematical method,* which is basically a step-by-step electronic copy of conventional pencil and paper solution techniques. Second is the method of *direct simulation,* which has the advantage of reducing the number of operational amplifiers required.

Mathematical Method: Differential equation of motion for the single degree of freedom system with viscous damping, Fig. 1, is

$$(D^2 + 2r\omega_n D + \omega_n^2)\, u = (2r\omega_n D + \omega_n^2)\, S(t) \qquad (1)$$

Solution to this equation is obtained by first rearranging terms and then integrating for velocity,

$$Du = \int D^2u = \int [(-2r\omega_n D - \omega_n^2)\, u + (2r\omega_n D + \omega_n^2)\, S(t)]\, dt \qquad (2)$$

Displacement is then given by a second integration,

$$u = \int Du\, dt \qquad (3)$$

These operations imply that, at the time integrations are made for Du and u, the values of Du, u, $DS(t)$, and $S(t)$ are known. Since the electronic analog simulator transmits information at 186,000 miles per second, this condition is fulfilled.

The mathematical operations indicated by Equation 2 are carried out by the circuit components and connections shown in Fig. 2*a*. For identification, the first resistor R_1 is labeled $-\omega_n^2 u$, the value of one of the terms in Equation 2. If the

[1]References are tabulated at end of article.

*Now at Duke University, Durham, N. C.

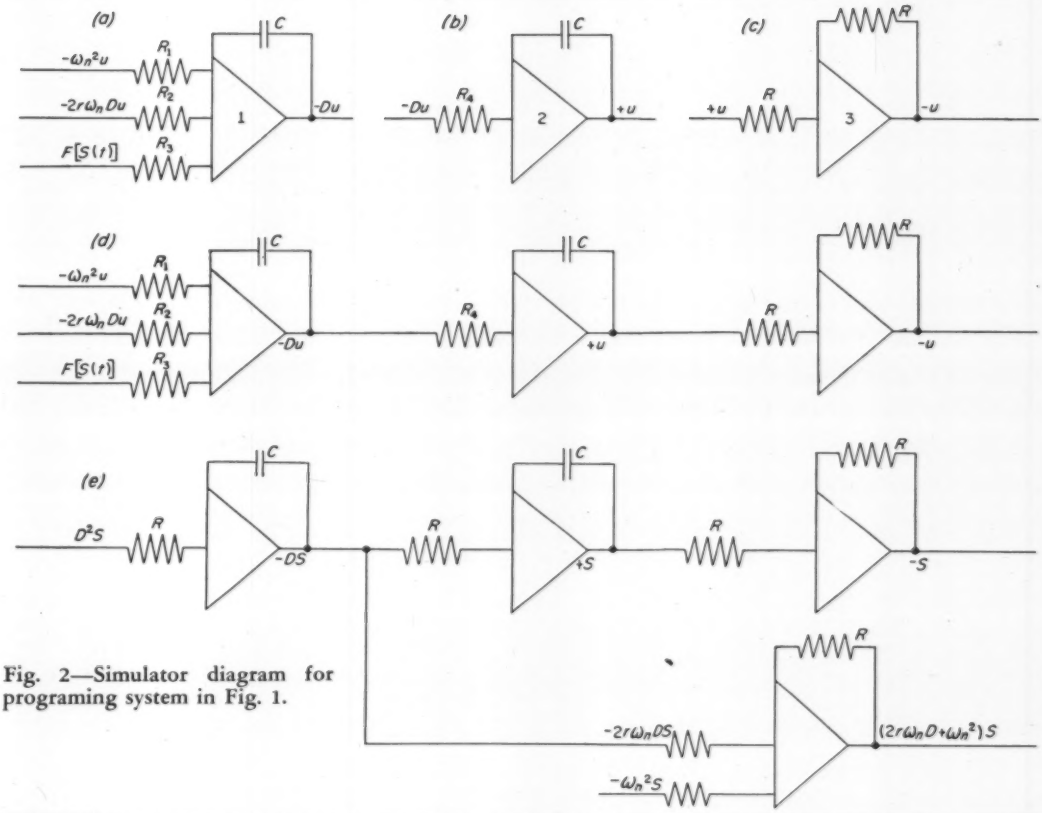


Fig. 2—Simulator diagram for programing system in Fig. 1.

value of this resistance is fixed at

$$R_1 = \frac{1}{\omega_n^2 C} \tag{4}$$

and the voltage to this resistor is proportional to $-u$, the output voltage for this term will be[1]

$$E_o = -\omega_n^2 \int u\, dt \tag{5}$$

Fixing the value of R_2 at

$$R_2 = \frac{1}{2r\omega_n C} \tag{6}$$

and connecting this resistor to the circuit point that has a voltage proportional to $-Du$ gives the output voltage corresponding to this term

$$E_o = -2r\omega_n \int Du\, dt \tag{7}$$

In similar fashion, the third resistor is given the value

$$R_3 = \frac{1}{C} \tag{8}$$

so that the output voltage contributed by the forcing function is

$$E_o = -\int FS(t)\, dt \tag{9}$$

Sum of these output voltages is obtained at

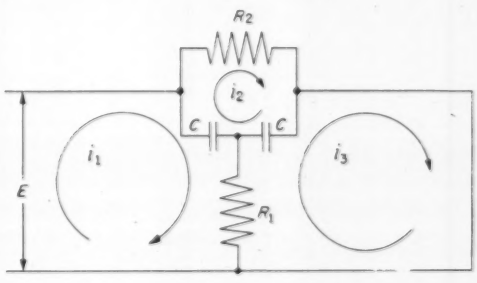


Fig. 3—Circuit illustrating use of Kirchoff's current law as step in derivation of transfer impedance function.

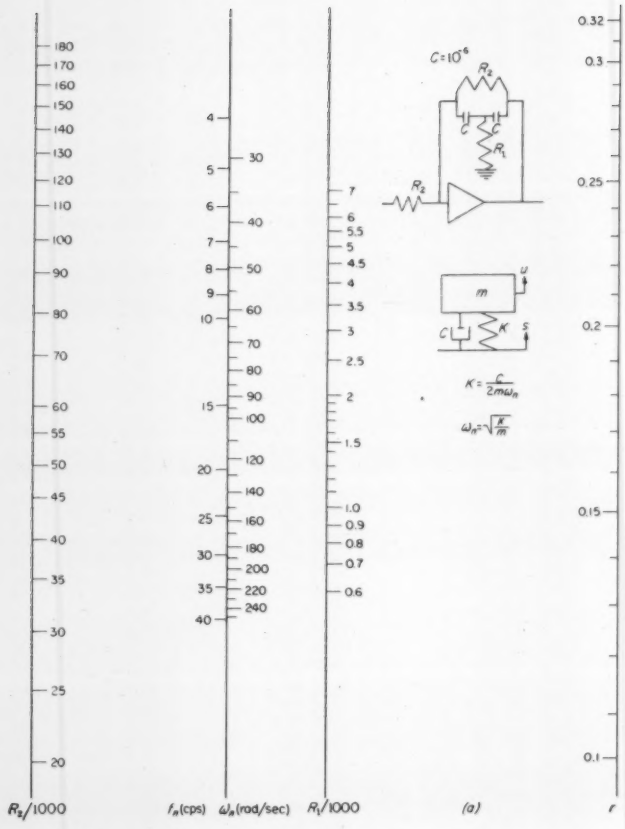


Fig. 4*a*—Nomograph giving network resistances for assumed values of natural frequency and damping ratio.

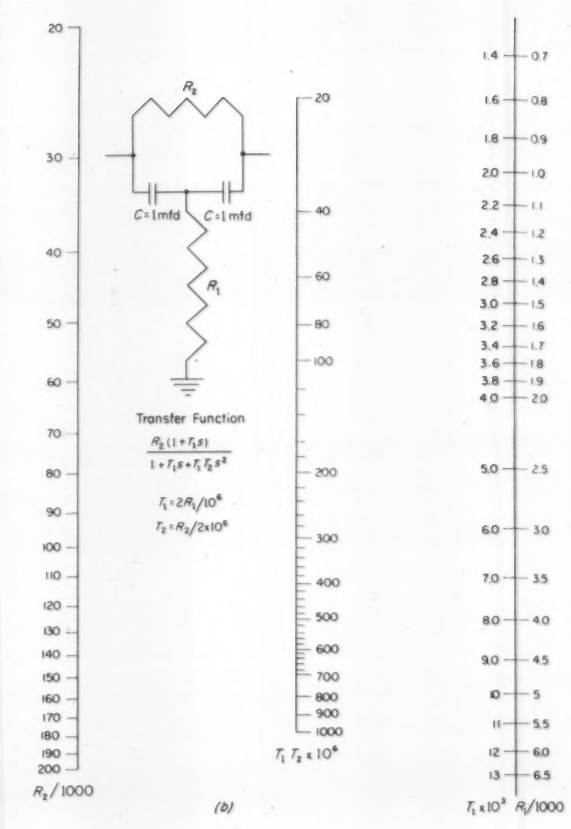


Fig. 4*b*—Nomograph giving transfer impedance function for known resistance and capacitance values in Fig. 3.

the output terminal of amplifier number 1 and, from comparison with Equation 2, is obviously proportional to velocity $-Du$, where the negative sign is applied because of the inverting action of the amplifier.

The voltage corresponding to $-Du$ is integrated in amplifier number 2, Fig. 2*b*, to give an output voltage corresponding to $+u$. This voltage is then fed into amplifier number 3 with equal input and feedback resistors to give a voltage corresponding to $-u$ as indicated in Fig. 2*c*. The complete diagram obtained by combining Figs. 2*a*, *b* and *c* is shown in Fig. 2*d*.

To generate the forcing function, $F[S(t)]$, it is generally best to start with the acceleration, D^2S, and by successive integrations obtain the necessary terms of the forcing function, as indicated in Fig. 2*e*. It is, of course, possible to start with the base displacement and obtain a voltage proportional to the base velocity by differentiation to obtain the term corresponding to $+2r\omega_n S(t)$. Since differentiation of a voltage accentuates any stray noise signal that may be present, it is usually easier and preferable to avoid differentiation.

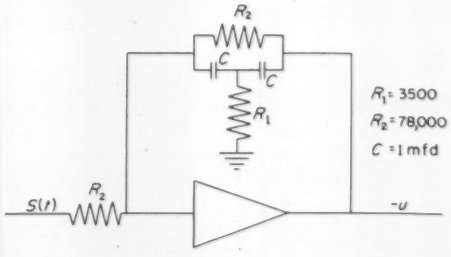


Fig. 5—Simulator diagram for single degree of freedom system of Fig. 1.

This mathematical method of solution treats the problem as an equation which is solved by the normal processes of addition and integration carried out electronically on the simulator. It is reasonably easy to understand this approach. However, it has the disadvantage of requiring a large number of operational amplifiers and, hence, a large computer for studying practical systems.

Direct Simulation: Solution by the method of direct simulation reduces the number of operational amplifiers by making ratio of feedback to input impedances analogous to the transfer function desired. Thus, rearranging Equation 1 as

$$\frac{u}{S(t)} = \frac{2r\omega_n D + \omega_n^2}{D^2 + 2r\omega_n D + \omega_n^2} = \frac{2rD/\omega_n + 1}{D^2/\omega_n^2 + 2rD/\omega_n + 1} \quad (10)$$

the problem may be simulated by use of the equation

$$\frac{E_o}{Ei} = -\frac{Z_f}{Z_i} \quad (11)$$

providing the impedance ratio Z_f/Z_i is of the same form as the right hand side of Equation 10.

The circuit shown in Fig. 3 will have the desired impedance transfer function. To show this, Kirchhoff's current law is used to obtain

$$(1 + R_1CD)\, i_1 - i_2 - R_1\, CD\, i_3 = ECD \quad (12)$$

$$-i_1 + (2 + R_2\, CD)\, i_2 - i_3 = 0 \quad (13)$$

$$-R_1\, CD\, i_1 - i_2 + (1 + R_1\, CD)\, i_3 = 0 \quad (14)$$

Solving these three equations for the ratio of the input voltage to the output current, the desired short-circuit transfer impedance function is given by the equation

$$Z = \frac{E}{i_3} = \frac{A(1 + T_1D)}{1 + T_1D + T_1\, T_2\, D^2} \quad (15)$$

where $A = R_2$; $T_1 = 2R_1C$; and $T_2 = R_2C/2$.

If the input impedance is a resistor with value equal to R_2, and the feedback impedance is the circuit of Fig. 3, Equation 11 will be identical to Equation 10 and the desired analogous system will be attained. Tables in Reference 2 and 7 give many useful combinations of resistances and capacitances for simulating a wide variety of transfer functions. Charts of the form of Fig. 4*b* are also helpful.

System with Single Degree of Freedom: To apply the method of simulation to the single degree of freedom system, Fig. 1, the following system characteristics are assumed: f_n = undamped natural frequency = 9.64 cps, and r = damping ratio = 0.212. From the nomograph in Fig. 4*a* (1 mfd capacitors), resistances are: R_1 = 3500 ohms, and R_2 = 78,000 ohms.

Fig. 5 shows the diagram used to program the problem on the simulator, using only one operational amplifier. Fig. 6 compares the response obtained for steady-state excitation on the simu-

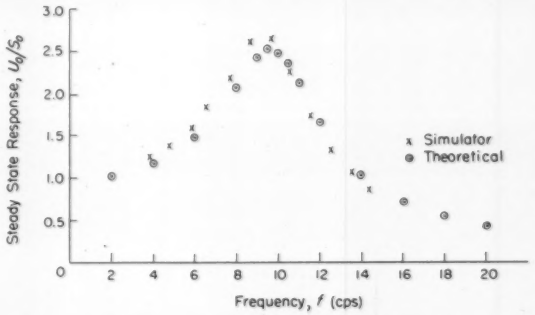


Fig. 6—Comparison of theoretical and simulator response for system in Fig. 1.

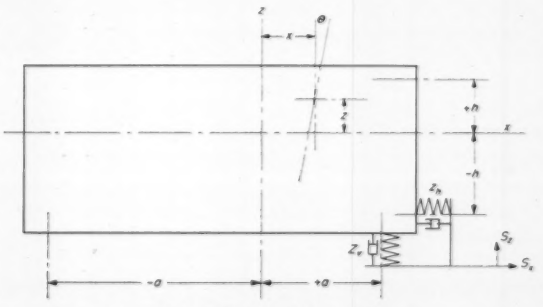


Fig. 7—Damped vibrating system with three degrees of freedom.

Nomenclature

- a = Horizontal distance from center of gravity to mount (Fig. 7), in.
- C = Capacitance, mfd
- c = Equivalent viscous damping coefficient, lb-sec per in.
- D = Differential operator, d/dt
- g = Acceleration due to gravity = 386 in. per sec^2
- h = Vertical distance from center of gravity to mount (Fig. 7), in.
- I = Mass moment of inertia, lb-in.-sec^2
- k = Spring constant, lb per in.
- m = Mass, lb-sec^2 per in.
- r = Viscous damping ratio, per cent of critical
- $S(t)$ = Excitation (function of time) applied to base Fig. 1), in.
- S_x = Input vibratory displacement of base (Fig. 7), horizontal direction, in.
- S_z = Input vibratory displacement of base (Fig. 7), vertical direction, in.
- u = Absolute displacement, in.
- x = Vibratory displacement of center of gravity (Fig. 7), horizontal direction, in.
- Z_h = Total mechanical impedence of mounts (Fig. 7), horizontal direction = $(k + cD)_h$, lb per in.
- Z_v = Total mechanical impedance of mounts (Fig. 7), vertical direction, lb per in.
- z = Vibratory displacement of center of gravity (Fig. 7), vertical direction, in.
- θ = Vibratory angular displacement (Fig. 7), rad
- ω_n = Undamped natural frequency, rad per sec

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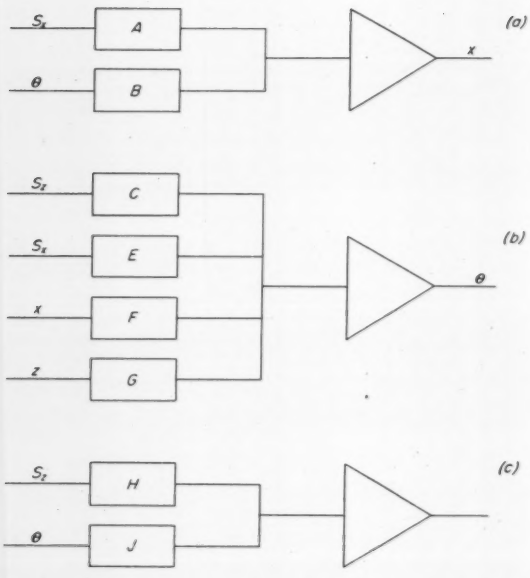

Fig. 8—Simulator diagrams for system with three degrees of freedom (Fig. 7).

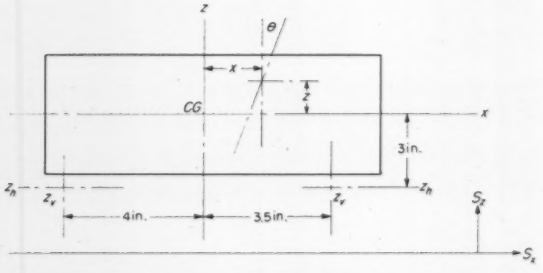

Fig. 9—Schematic of assumed vibrating system with three degrees of freedom.

lator with the calculated theoretical response. It will be noted that there are slight errors in both frequency and magnitude. These errors could be reduced by using precision resistors and capacitors and by making allowance for changes in potentiometer resistance with voltage. In view of the difficulty of correctly ascertaining spring stiffness, weight and damping present in any physical system, such refinement does not appear to be necessary here.

Simulation Applied to Three Degree of Freedom System: Multidegree of freedom systems are simulated on the analog in a manner quite similar to that for the system with a single degree of freedom. Discussion here is limited to the system shown in Fig. 7, which represents apparatus supported on mounts with both resilience and damping. Damping and spring gradient are assumed linear. It is also assumed that coupling between modes in the plane of the paper is strong, while coupling between modes in the plane of the paper and modes in planes at right angles to the paper is weak and may be neglected.

Differential equations of motion for the system are

$$mD^2x + x \Sigma Z_h + \theta \Sigma Z_h h = S_x \Sigma Z_h \qquad (16)$$

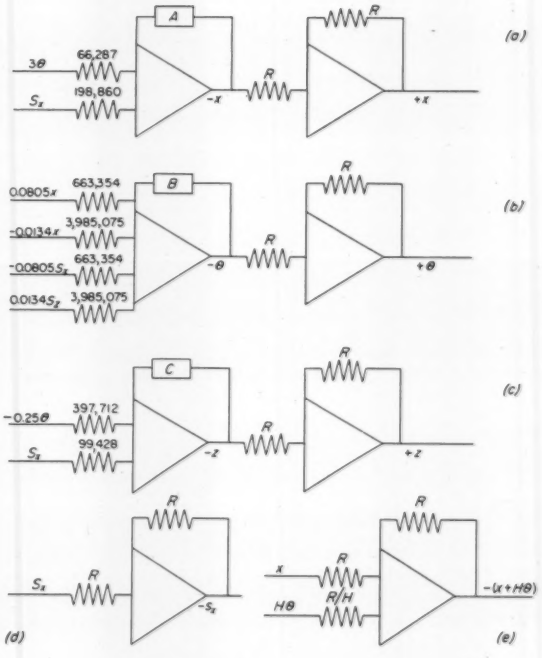

Fig. 10—Simulator diagrams for assumed system (Fig. 9).

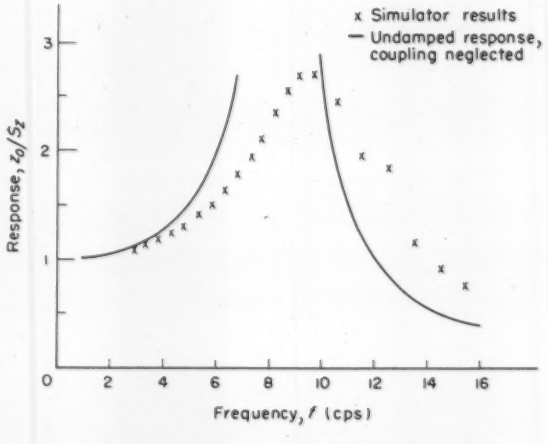

Fig. 11—Steady-state vertical response to vertical input for system in Fig. 9.

$$ID^2\theta + \theta \Sigma Z_h h^2 + \theta \Sigma Z_v a^2 + x \Sigma Z_h h + z \Sigma Z_v a = S_z \Sigma Z_v a + S_x \Sigma Z_h h \quad (17)$$

$$mD^2 z + z \Sigma Z_v + \theta \Sigma Z_v a = S_z \Sigma Z_v \quad (18)$$

These equations may be rearranged to give values of the displacements in terms of transfer functions by solving Equation 16 for x, Equation 17 for θ, and Equation 18 for z. This gives

$$x = \frac{S_x \Sigma Z_h}{mD^2 + \Sigma Z_h} - \frac{\theta \Sigma Z_h h}{mD^2 + \Sigma Z_h} = AS_x + B\theta \quad (19)$$

$$\theta = \frac{S_z \Sigma Z_v a}{ID^2 + \Sigma Z_h h^2 + \Sigma Z_v a^2} + \frac{S_x \Sigma Z_h h}{ID^2 + \Sigma Z_h h^2 + \Sigma Z_v a^2} - \frac{x \Sigma Z_h h}{ID^2 + \Sigma Z_h h^2 + \Sigma Z_v a^2} - \frac{z \Sigma Z_v a}{ID^2 + \Sigma Z_h h^2 + \Sigma Z_v a^2} = CS_z + ES_x + Fx + Gz \quad (20)$$

$$z = \frac{S_z \Sigma Z_v}{mD^2 + \Sigma Z_v} - \frac{\theta \Sigma Z_v a}{mD^2 + \Sigma Z_v} = HS_z + J\theta \quad (21)$$

where A, B, etc., represent the impedance transfer functions indicated. Equations 19, 20 and 21 provide the clue to the next step in programing this problem. As indicated in Fig. 8*a*, it is assumed that S_x and θ are known. The voltage representing S_x is applied to an amplifier having input and feedback impedances such that the impedance transfer function is equal to A. Likewise, the voltage representing θ is applied to an amplifier having input and feedback impedances such that the transfer function is equal to B. Outputs from these two amplifiers are added together in a third amplifier, giving an output voltage proportional to the displacement x. The same general procedure is followed in Fig. 8*b* to obtain θ, and in Fig. 8*c* to obtain z.

Application to an Assumed System: To illustrate application of the principle of direct simulation, the vibratory response of the box shown in Fig. 9 will be studied. Assumed characteristics of the box and its mounts are: $m = 0.02332$ lb-sec^2 per in.; $I = 0.02332$ lb-in.-sec^2; $Z_h = (0.235D +$

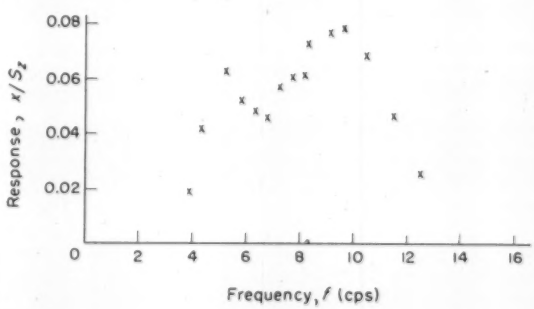

Fig. 12—Horizontal response to vertical input for system in Fig. 9.

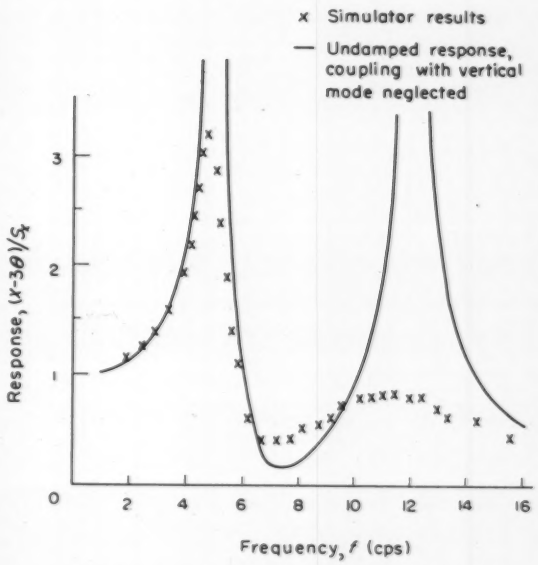

Fig. 13—Horizontal displacement of point 3 in. below center of gravity for horizontal input.

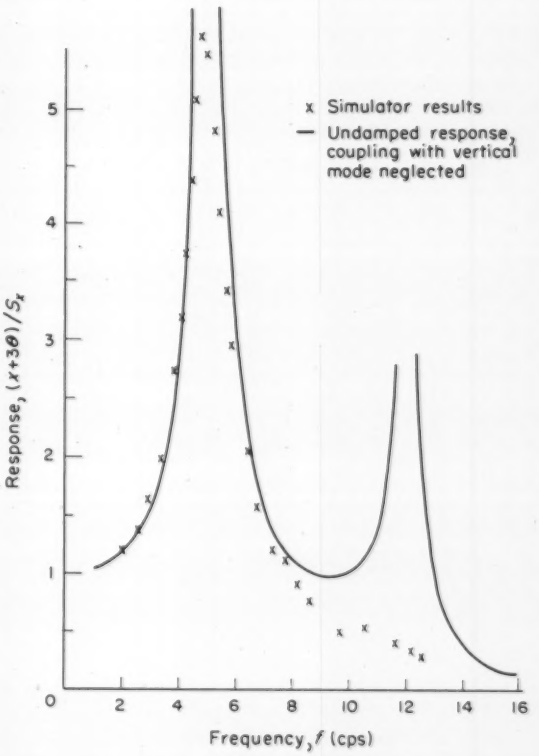

Fig. 14—Horizontal displacement of point 3 in. above center of gravity for horizontal input.

33.5) lb per in.; and $Z_z = (0.47D + 67)$ lb per in.

With this data and the dimensions shown in the figure, the differential equations are

$$(0.02332D^2 + 0.235D + 33.5)x = (3\theta + S_x)(0.235D + 33.5) \quad (22)$$

$$(0.2332D^2 + 8.779D + 1247.88)\theta = (3x = 3S_x)(0.235D + 33.5) + (0.25S_z - 0.25z)(0.47D + 67) \quad (23)$$

$$(0.02332D^2 + 0.47D + 67)z = (S_z - 0.25\theta)(0.47D + 67) \quad (24)$$

Simplifying these equations gives

$$x = \frac{(3\theta + S_x)(0.007D + 1)}{0.000696D^2 + 0.007D + 1} \quad (25)$$

$$\theta = \frac{(0.0805x - 0.0805S_x + 0.0134S_z - 0.0134z)(0.007D + 1)}{0.0001869D^2 + 0.007D + 1} \quad (26)$$

$$z = \frac{(S_z - 0.25\theta)(0.007D + 1)}{0.000348D^2 + 0.007D + 1} \quad (27)$$

The diagrams for programing Equations 25, 26, and 27 on the plug board are shown in Figs. 10*a*, *b* and *c*. Feedback impedances shown by the blocks *A*, *B* and *C* are of the circuit form shown in Fig. 3. To reduce the number of amplifiers required, inputs to the amplifiers have suitable loading resistors. That is, in programing Equation 25, the loading resistors are selected so that the net input is $(3\theta + S_x)$. With 1 mfd capacitors in the feedback networks, the resistances required are obtained from Fig. 4*a* and listed in Table 1.

Input resistances are obtained by noting that R_2 is a multiplier for the feedback impedance network used here. These input resistances are listed in Table 2.

The negative S_x required is obtained by using an amplifier to invert the sign of this voltage as shown in Fig. 10*d*. Fig. 10*e* shows the method used to obtain the total horizontal response at some point on the box *H* in. distant from the center of gravity.

The steady-state response obtained on the analog simulator for this particular system is shown in Figs. 11 to 15, inclusive. Points in Fig. 11 show vertical response of the center of gravity to vertical excitation. The solid line is the calculated response for the vertical direction, neglecting damping and coupling with other modes. Response obtained on the analog shows the effect of coupling in the region of 12 to 14 cps near the upper rocking natural frequency.

Fig. 12 shows the horizontal response of the

Table 1—Feedback Resistances

Network	Resistances (ohms)	
	R_1	R_2
A	3500	198,860
B	3500	53,400
C	3500	99,430

Table 2—Input Resistance

Item	Resistances (ohms)	
	R_2	Input
3θ	198,860	66,287
S_x	198,860	198,860
$0.0805x$	53,400	663,354
$-0.0134z$	53,400	3,985,075
$-0.0805S_x$	53,400	663,354
$0.0134S_z$	53,400	3,985,075
-0.25θ	99,428	397,712
S_z	99,428	99,428

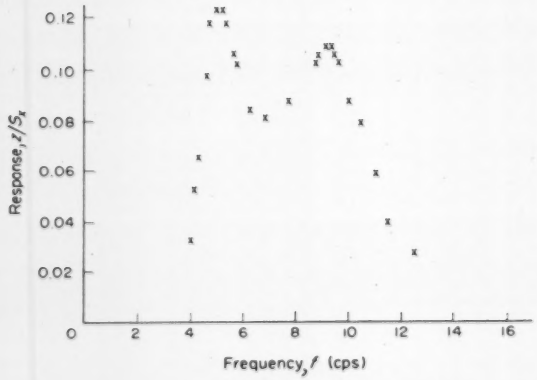

Fig. 15—Vertical response of center of gravity to horizontal input.

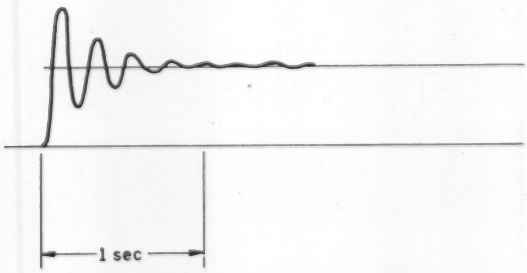

Fig. 16—Response in horizontal direction of point 3 in. above center of gravity to a horizontal step displacement.

center of gravity to vertical excitation. This response is small since the coupling in this case is weak. The lower peak in the response curve is near the lower rocking natural frequency, while the upper peak is near the vertical natural frequency.

Fig. 13 shows the horizontal response of a point 3 in. below the center of gravity to horizontal excitation, while Fig. 14 shows the horizontal response of a point 3 in. above the center of gravity for the same excitation.

Solid lines are the undamped response calculated when coupling with the vertical mode is neglected.

Fig. 15 gives the vertical response of the center of gravity to horizontal excitation. As in the similar case of Fig. 12, response is low since coupling is weak. Response peaks both at the lower rocking mode and at the vertical mode. The damping is sufficiently large in this case to preclude appreciable response at the upper rocking frequency.

Fig. 16 shows the horizontal response 3 in. above the center of gravity to a horizontal step displacement equal to $(x + 3\theta)/S_x$. With suitable function generators for excitation, it should be feasible to determine the response of this, or similar systems, to the types of shock encountered in actual practice.

ACKNOWLEDGEMENT

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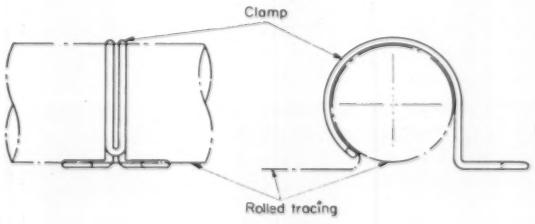
Tips and Techniques

Roll Holder

Wire cable clamps may be used to hold tracings or other rolls of paper in the rolled condition. Number of clamps to be used is, of course, determined by the length of the roll. If not readily available, these clamps may be easily bent from coat hangers.—EDWARD O. FERDINAND, *Chicago, Ill.*

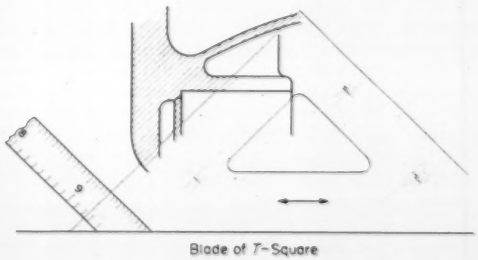


Ellipses With a Compass

Small ellipses may be drawn with a drop compass by holding the compass at an angle to the paper. First adjust the compass to half the minor axis length. Then place the compass point at the ellipse center. Tilt the compass as far as required to bring the lead point to the end of the major axis. Then rotate the pencil point maintaining the angle constant. The pencil must be sharpened to a fine conical point. A chisel point will not work.—CHARLES H. ISAACS, *Philadelphia, Pa.*

Crosshatching Guide

Graduations on a flexible steel rule may be used as crosshatching guides. The rule is placed under the straightedge or drafting machine blade as shown.—EWALD SCHLACHTER, *Oshkosh, Wis.*



Tips and Techniques

Reducing Repetitive Drawing Time

A DRAFTSMAN often finds that a portion of a drawing must be repeated somewhere else on the same sheet. If it is already drawn on the main sheet, it can be duplicated elsewhere by tracing it on a scrap of transparent paper, slipping this under the main sheet at the second location, then tracing it back on the original drawing. Often, the first tracing operation dulls the linework on the original, and the second tracing transfers some pencil lead to the under side of the main sheet. Hence the first detail on the main drawing will tend to reproduce relatively faintly, while the second identical detail will be extra dark.

If the draftsman knows in advance that certain portions will be duplicated, he can draw them on a small piece of paper, using a harder pencil than usual so that very little lead will transfer during the tracing. The paper should be large enough so that at least one edge will extend out from below the main sheet for convenient handling.

The detail can be accurately but roughly drawn. Centers of circles, arcs and fillets should be clearly marked to speed up tracing. The paper is adjusted under the main sheet in each of its respective positions and the detail is traced as many times as needed. For opposite-hand views, the paper must be transparent so that it can be turned face down while being traced. To keep lead off the backing sheet on the drafting board, another piece of paper should be interposed below the face-down detail.

This method of tracing repetitive details is not only faster, but also reduces errors and keeps the drawing cleaner.

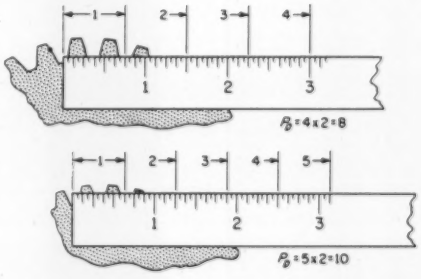
Typical cases where tracing is an aid are:

1. Opposite-hand views.
2. The two halves each side of the centerline of a complicated, symmetrical shape. The shape may have other portions not symmetrical.
3. The four quarters of a complicated shape largely symmetrical about two axes, such as an elliptical object.
4. Guide lines for long, hand-lettered notes.
5. Views and sections which have the same outline.
6. Views which require a great deal of construction.
7. Views or sections located on a drawing in a position which will not permit the easiest method of drawing by projection. For example, an end elevation may be easier to project from the plan view, yet is usually shown in line with the side elevation. In such cases, after the primary view is drawn on the main sheet, place a scrap of paper over the drawing in the most convenient position to project the secondary view. When the latter is completed on the separate sheet, place it under the main drawing and trace it in its conventional position.
8. Parts of an assembly, or auxiliary views on a detail drawing at awkward angles. It may be easier to draw them on a scrap of paper, parallel to the edges of the drafting board, and then trace them at the correct angle.
9. Assemblies or schematics that show the same parts in two or more different relative positions.
10. Repetitive subassemblies in an assembly drawing (such as rollers in a conveyor) and repetitive details in a part drawing (such as identical clover-leaf bosses for pipe connections on a multiport valve body).
11. Design study layouts, where the location of some subassemblies or of some individual parts depends on the space available, and on the orientation of adjacent parts. Details can be drawn on separate pieces of paper, then adjusted under the main drawing to their best position relative to the other details, and traced. It may also be necessary to use cut-outs.

—W. GOVAN, *Cooper Union, New York, N. Y.*

Determining Diametral Pitch

An ordinary scale may be used to determine the approximate diametral pitch of a spur gear or portion of a gear. Place the zero point of the scale halfway between two teeth at the approximate pitch diameter and note the measurement of two pitches on the scale. Then, on the scale, count off as many of these measurements as possible up to the 3-in. graduation on the scale. This



times two is diametral pitch. As shown by the second sketch, small departures may be ignored in order to arrive at an even answer.—MERTON O. HODGES, *General Electric Co., Lynn, Mass.*

Covering Drawing Boards

To place a smooth, tight, bubble and wrinkle-free cover on a drawing board first cut the cover paper to size allowing about 2 in. of overlap all around. Next, turn back side of the paper up and use a damp rag or paper towel to thoroughly soak the cover. Then turn the paper over and stretch and staple it in place. Bubbles may appear but after a short drying time, a taut, smooth cover will result.—H. M. BROWN, *South Bend, Ind.*

DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY

The purpose of test points is to provide the technician with signals for checking, adjusting or trouble shooting electronic equipment. Test points must be physically located for easy accessibility and also tied into the proper location in a circuit to obtain required signals. Recommendations for location and groupings of test points are presented here.

Design recommendations for TEST POINTS

By John D. Folley Jr. and James W. Altman

Research Scientists, American Institute for Research, Pittsburgh

PROPERLY placed test points are indispensable to effective design for maintainability. They provide the technician his only practical means of looking into the functioning of a system, except for the information obtainable from operator displays.

Test-Point Functions: Test points make signals available to the technician for checking, adjusting, or trouble shooting electronic equipment. To be of maximum benefit for any of these functions, test points must be in the proper functional location; that is, they must tie into the circuit where a technician may require sample signals, and the physical location of test points should be such that the technician can reach them easily. Test points should be labeled for easy identification and designed for easy attachment of test equipment. The most important use of test points is in trouble shooting. The majority of recommendations given in this article pertain to this use.

Test-Point Voltage Data: Test points should permit measurement of the signals that carry information through the system circuitry as well as the various power-supply voltages used in the equipment. Out-of-tolerance signals usually cause the final output of the system to be unsatisfactory. If the final system output is not satisfactory, it should be possible to determine what portion of the system is malfunctioning by tracing signals until a point is located that is out of tolerance. This trouble-shooting technique is virtually impossible if signals are not brought out to test points.

Maintenance Procedures and Test-Point Location: Maintenance procedures and specifications for test points should be prepared concurrently with the design of electronic equipment so that necessary compromises can be made between technical limitations and optimum procedure design. Physical location of test points must also be considered in this development, since the feasibility of a certain functional location may be determined by the physical location that can be provided.

For example, it may only be feasible to provide a test point for a given point in a circuit if the lead to that test point is no more than 1 or 2 inches in length to prevent losing the signal in transmission. If the physical location of a test point that would meet these requirements were such that the technician could not reach it, a substitute procedure and functional location for the test point would have to be found so that the physical loca-

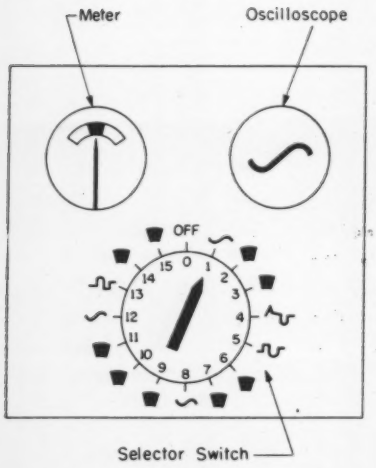


Fig. 1—Test-point grouping consisting of a built-in meter, an oscilloscope for indication and a rotary switch for circuit selection. Either the proper meter reading or the oscilloscope waveform is illustrated at each switch position around the selector.

tion of the test point would be satisfactory.

Functional Locations: A designer can fix the functional location of test points by determining from the maintenance procedures what signals must be available to the technician and at what points they must be available. Test points merely make available those signals that the maintenance procedures dictate the technician needs to maintain a piece of electronic equipment. This means that test points should not be randomly placed throughout the system wherever it is technically convenient, but rather they must be planned into the system. For customer maintenance, for example, a test point should be available for each input and output of each customer-replaceable unit.

Physical Locations: The physical location of test points determines their ease of use and the likelihood that the procedures for which they were included will be followed. In this way the physical location of test points has a marked effect on the quality of maintenance.

Generally, test points should be concentrated in one place. Practical limitations do not always permit this arrangement. The nature of a signal may be such that it does not travel well without being altered in the process of transmission. The designer should keep in mind, however, that it is not mandatory that the technician be able to sample the true signal as it appears in a circuit. All that he may need is an indication that reflects an out-of-tolerance condition of the true signal when one exists. If these indications are checked and recorded during engineering tests, they should be adequate for field use. This consideration is particularly pertinent where the wave shape of the signal is critical and will tend to change in transmission to the test point.

Test points should be accessible in the particular installation. Internal test points should be clustered around the portion of the units that will be most accessible when installed. For example, the side of a unit containing the operator's controls and displays is likely to be more accessible for maintenance than the side of the unit opposite the controls.

In airborne equipment, test panels should be located just under the skin of the aircraft and made accessible through an access door, or else they should be located so that they can be conveniently reached from the crew's compartment.

In ground equipment, the test panels should be above 4 to 5½ ft from the surface on which the technician will stand while using the panels.

Grouping of Test Points: Suggested groupings of test points are given here with the one judged most desirable presented first, the next best second, and so on. These arrangements are merely samples and are not intended to exhaust all possible ways in which test points can be arranged. They are presented to help the designer evaluate the adequacy of his own plans for test-point arrangement.

Built-In Meter and Scope: This arrangement, Fig. 1, built in as part of the installation, seems best. It assumes that not only voltages but also wave shapes must be checked for trouble shooting or system checkout. Note that the meter and oscilloscope have fixed preset circuits so that the meter always reads center scale and the oscilloscope needs no adjustment. An in-tolerance reading for each switch position is illustrated on the switch face.

Portable Meter and Scope: If the preceding ar-

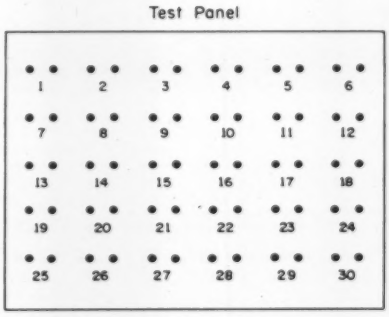


Fig. 2—Panel of numbered test points for checking operation of electronic equipment. Overlays can be made to guide technicians to the desired test points. Exact in-tolerance signals or waveforms can be shown on the overlays for each test point.

rangement is not practical because of space or weight limitations, a portable test box similar to the built-in device just described could be employed. Such a test box should have a single multiprong contact for attachment to a central test panel.

If more test points are needed than can be handled by a single switch in either of the two arrangements just discussed, a multiple switch arrangement can be used.

Test-Point Panel: If the auxiliary equipment illustrated in Fig. 1 cannot be provided, at least a test panel, Fig. 2, should be added to the equipment. Standard test equipment can be used by the technician in conjunction with the use of this panel. Such an arrangement provides, in effect, a miniature block diagram of the system with each block representing a customer-replaceable unit. In this design a test point is provided for the input and output of each customer-replaceable unit to permit isolation of circuit malfunctions in a particular unit. Various overlays for the panel should be co-ordinated with maintenance procedures and should be designed to direct the technician to those test points that he should check and in the order in which he should check them. Exact intolerance signals can be shown on the various overlays for each test point, even though the signals change at various steps in the checking or trouble-shooting procedures.

Test points should be coded on the panel for identification in the event that overlays are lost. A code key should be included in job instructions.

Built-In Meter and Outlet Jacks: If a central test panel for the system is not feasible, ideally a test panel of the type illustrated in Fig. 1 should be used on each major unit. Since this may not be practicable in many cases because some oscilloscopes are large, heavy and expensive, the arrangement shown in Fig. 3 is suggested.

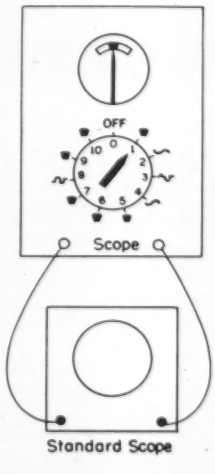


Fig. 3 — Test-point arrangement in which meter and selector switch are built in and a plug outlet is provided for applying signals to a separate oscilloscope.

Mount a center-reading meter on each major component for those signals that can be checked by meter. Provide a set of test jacks on each major component that can serve as an outlet for signals requiring an oscilloscope when selected by the switch. The selector switch should be similar to those suggested in Fig. 1.

If this arrangement cannot be used, the panel of test jacks as described in the second alternative should be used on each major component.

Test Points on Customer-Replaceable Units: If none of the preceding suggested arrangements are feasible, test points for customer maintenance should still be provided for the inputs and outputs on each customer-replaceable unit. This design is by far the least desirable from the standpoint of ease and speed of maintenance. Particular design attention should be given to making these test points as accessible as possible, if this alternative must be used.

All test points should be placed or guarded so that the technician is physically prevented from contacting high voltage while using them.

Labeling of Test Points: Each test point should be labeled with a symbol or name attached only to that particular point.

Each test point should be labeled with the intolerance signal and tolerance limits which should be measured there. A designation of the unit whose output is available at a given test point should be included in the label.

If it is not feasible to present this information on the test point, it should be included in job instructions and coded to the test point.

Test points should have an outstanding color to permit easy location in the equipment. Ideally, luminescent markings should be used on test points, including selector switches and meters, where readings must be made in very low illumination.

Connections to Test Points: No more than one full turn of a connector should be required to connect test equipment to a test point.

If maintenance procedures require that a test probe retain connection to a test point without being held by the technician, the test point should contain a quick-disconnect fastener to prevent the probe from falling out.

Test Points for Field and Factory Maintenance: A test point, which may be nothing more than a bare wire, should be supplied at the input and output for each part of a throwaway unit. One convenient way to provide these test points is to mount components on one side of a board and wiring on the other side with electrical connection through the board. Even if the wiring is mounted on the same side as the parts, test leads

can be brought through to the back of the board. An advantage to having test points alone on a flat surface rather than in among the parts is that full identifying information for each test point can be stamped on the surface without being obscured by the parts.

Each wire should be labeled with a unique designation. This makes trouble shooting using wires easier since identification is easier. Provision should be made for technicians to label each wire they replace.

It should not be necessary to remove any assembly from a major unit to trouble shoot that assembly. This may require special test points on the major units or assemblies.

Test equipment or bench mock-ups should provide access to the outputs and inputs of each customer-replaceable unit through the normal interconnecting plugs. It should be possible for the field or factory technician to check out each customer-replaceable unit without special test points being mounted on the unit.

Checking and Adjustment Considerations: For customer checking, test points are likely to have limited use, to supplement information provided by the operator's displays. For field and factory checking they are likely to be used only to supplement information taken at normal output channels of the unit being checked. Because checking is likely to follow a relatively inflexible sequence of steps, test points used in checking should be located close to controls and displays that are also employed in the checking operations.

Each test point used in adjusting at the customer, field and factory levels will preferably be directly associated with only one adjustment control. The signal available at such a test point should indicate unambiguously when the associated control has been moved to the required position. It should also be located so the technician operating the control can read the signal available at the test point.

BIBLIOGRAPHY

This article is the sixth in a co-ordinated series by John D. Folley Jr. and James W. Altman. Previous articles, and issues of MACHINE DESIGN in which they appeared are:

Designing Electronic Equipment for Maintainability ..... June 14, 1956
Units, Assemblies and Subassemblies .. June 28, 1956
Covers and Cases ..... July 12, 1956
Wiring, Cables and Connectors ..... July 26, 1956
Maintenance Accesses ..... Aug. 9, 1956

Tips and Techniques

Computing Square Roots

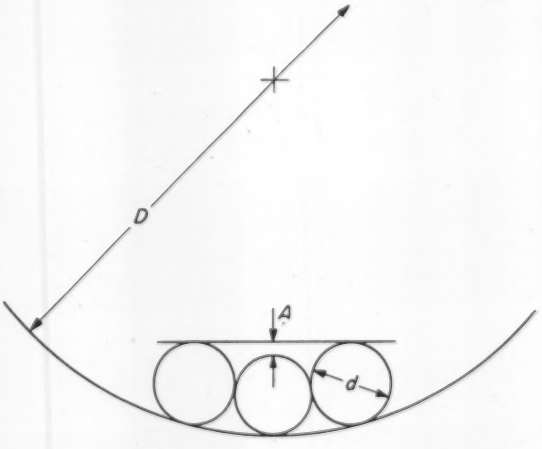
There are times when no tables are available and it becomes necessary to compute square roots. A quick way to do this using either a pencil and paper or a computing machine is to estimate a solution and then divide the radicand by this approximation. The arithmetic mean between the resulting quotient and the first approximation is a second, closer approximation which may be sufficiently accurate in many cases. If higher accuracy is required, the process is repeated using the second approximation, etc. As an example, to find the square root of 500:

1. Estimate 22
2. $500 \div 22 = 22.72$
3. $(22 + 22.72) \div 2 = 22.36$

Value of the square root of 500 given in 5-place tables is 22.36068. By repeating the process once more using 22.36 as the approximation, this value is obtained.—RICHARD H. HEIMANN, *Flushing, N. Y.*

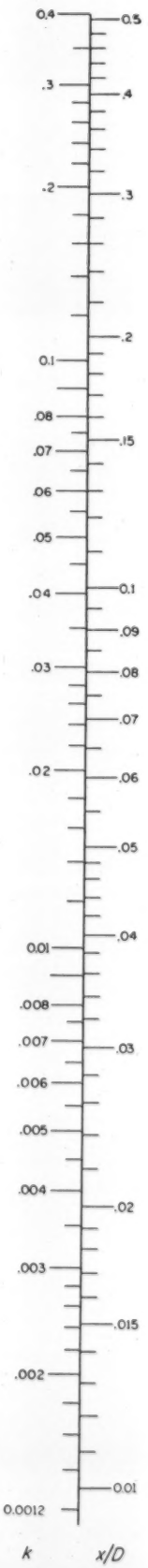
Measuring Bores

When the necessary measuring devices are not available or it is impossible to measure a bore diameter by conventional methods, three rollers or cylinders of equal and known diameter may be used to obtain the diameter. A straightedge is placed upon the rollers as shown and dimension A measured. Then the bore diameter, D, is found

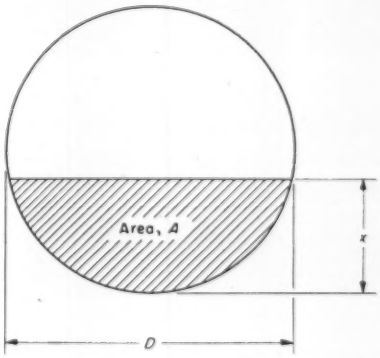


by using the formula, $D = d + (d^2/A)$.—MERTON O. HODGES, *General Electric Co., Lynn, Mass.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.



Conversion scale simplifies calculation of Areas of Circle Segments



By R. J. Keery
Development Engineer
Short Bros. & Harland Ltd.
Belfast, Ireland

CALCULATING partial areas of circles—segments—is a tedious operation. Yet, the problem arises frequently, for example, in the design of hydraulic servo valves incorporating circular holes as ports—or in the calculation of partial volumes in circular tanks.

The basic equation is

$$A = \frac{\pi D^2}{8} - \left(\frac{D}{2} - x\right)\sqrt{Dx - x^2} - \frac{D^2}{4}\sin^{-1}\left(1 - 2\frac{x}{D}\right)$$

For convenience in a graphical solution, this equation can be converted to

$$A = \left[\frac{\pi}{8} - \left(\frac{1 - 2\frac{x}{D}}{2}\right)\sqrt{\frac{x}{D} - \left(\frac{x}{D}\right)^2} - \frac{1}{4}\sin^{-1}\left(1 - 2\frac{x}{D}\right)\right]D^2$$

Letting the bracketed terms be denoted by k gives

$$A = k\,D^2$$

The scale at the left provides direct conversion from ratio x/D to k, for x/D = 0.01 to 0.5. The required area is then simply $k\,D^2$. For values of x/D greater than 0.5, such as 0.8, k can be found for $x/D = 1.0 - 0.8 = 0.2$ and subtracted from $\pi/4$. That is, from the scale for $x/D = 0.2$, $k = 0.11$. For $x/D = 0.8$, $k = 0.7854 - 0.11 = 0.6754$.

Example: Find the area for x = 0.3-in. and D = 0.8-in. Ratio $x/D = 0.375$. From the conversion scale, $k = 0.265$. Area $A = k\,D^2 = 0.265(0.64) = 0.170$ sq in.

DESIGN ABSTRACTS

How to determine

Capacity of Nylon Plastic Gears

By K. W. Hall and H. H. Alvord

Mechanical Engineering Dept.
University of Michigan
Ann Arbor, Mich.

NONMETALLIC gears have been made and used for a long time. Various materials have been used successfully, and the particular qualities of these materials have been utilized in many installations. These qualities often include quietness of operation, ability to absorb shock loads, resistance to corrosion, and ability to operate with various fluids used as lubricants. When such gears can be molded to their final form, ease of manufacture becomes a very important quality of the nonmetallic gear.

In recent years many new plastic molding materials have been developed, some of them having characteristics which make them suitable for gears and similar mechanical parts. One such material is Zytel 101, a nylon resin manufactured by Du Pont Co.

The Material: Nylon is thermoplastic and is supplied in the form of a granulated powder from which various products can be molded by conventional molding techniques. Molded Zytel nylon is a relatively lightweight, rigid, but not brittle, material. Zytel is made in several varieties, of which Zytel 101 is the most heat-resistant and best suited for mechanical parts. In the molded form it is easily machined. Typical physical properties of this material are given in Table 1.

Table 1—Physical Properties of Moisture-Conditioned Zytel 101

Tensile strength at 70 F	9300 psi
Elongation at 70 F	220 per cent
Modulus of elasticity at 73 F	200,000 psi
Shear strength	8000 psi
Impact strength, Izod, at 73 F	2.0 ft-lb/in.
Hardness, Rockwell R	108
Specific gravity	1.14

These physical properties are considerably affected by temperature. For example, Fig. 1 shows how the tensile strength decreases with higher temperature, while the impact strength increases.

The physical properties are further affected by moisture content of the molded material. Moisture content also affects the dimensional stability of the finished part. When the material is conditioned after molding to have a moisture content of about 2.5 per cent by weight, however, the material has good dimensional stability. All the physical properties shown in Table 1 are for this 2.5 per cent moisture-conditioned, molded Zytel 101.

Test Gears: Although in the majority of cases, gears made of Zytel 101 will have molded teeth, test results described here were obtained with three sets of gears

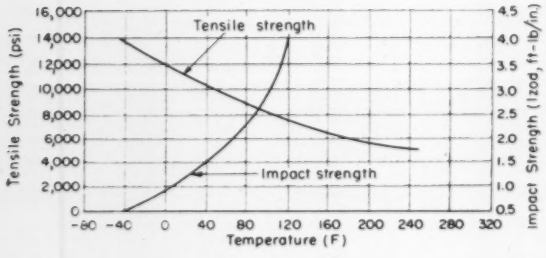


Fig. 1—Effects of temperature on tensile and impact strengths of Zytel 101 nylon.

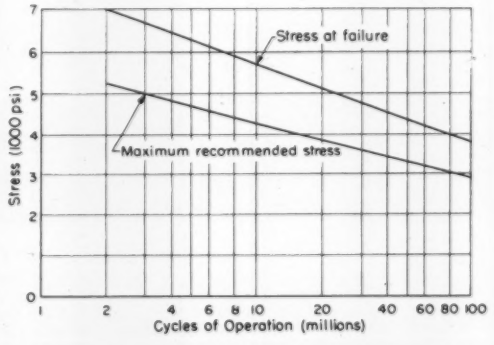


Fig. 2—Stress at failure and recommended stress for lubricated spur gear teeth hob cut from molded Zytel 101.

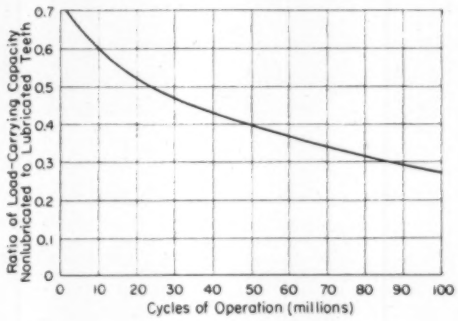


Fig. 3—Load-carrying ratio of lubricated and nonlubricated teeth.

having hob-cut teeth rather than molded teeth.* Cut teeth were used to allow greater flexibility in the manufacture of test gears at the start of the evaluation program.

Each set of gears tested consisted of the 20 gears required to fill five test machines, plus a few extra gears to be used as replacements when tooth failure occurred. The first and second sets of gears were identical, having 50 teeth, 20 pitch, 2½-in. pitch diameter, 20-deg pressure angle, and 7/16-in. face width. The third set had 40 teeth, 16 pitch, 2½-in. pitch diameter, 20-deg pressure angle, and 7/16-in. face width. All gears had full-depth teeth.

The test gears were machined from molded Zytel blanks with commercial class 4 hobs. Maximum total composite error was 0.0013-in. for all the gears taken together, while maximum tooth-to-tooth composite error was 0.0006-in.

Load-Carrying Capacity with Lubrication: Results of tests showed that when the teeth are lubricated, load-carrying capacity of the teeth is governed by breaking strength of the teeth and not by the rate at which the teeth wear. This same thing is true of the nonlubricated teeth, although the life of the teeth prior to breaking is considerably reduced when no continuous lubrication is provided. When the teeth are cleaned with a solvent prior to operation, however, load-carrying capacity is greatly reduced and is governed by the rate at which the teeth wear rather than by breaking strength.

When lubricated, the teeth fail at the root in a manner that has the appearance of a typical bending-fatigue failure. At lower torque loads, failure occurs at a successively greater number of cycles, again indicating fatigue failure.

The upper line of Fig. 2 was drawn from the test results and is considered to show the bending-failure stress for any given number of cycles, when the teeth are lubricated. It will be noticed that the failure stress continues to decrease with the number of cycles, indicating that this material has no definite flexural endurance limit, or stress below which the teeth can operate indefinitely without failure.

The data of Fig. 2 were obtained with the 16 and 20-pitch hob-cut teeth previously described, operating with pitch-line velocities from 1150 to 2260 fpm and with oil-mist lubrication. Alignment of the test gears was virtually perfect, inertia of the rotating parts was relatively small, and the load was constant. Nevertheless, it is felt that these same data should apply reasonably well to other installations where tooth size, velocities, and other conditions are not too much different than the conditions described. Because the ideal conditions of test-stand operation will seldom be duplicated in any particular installation, a reasonable margin of safety probably should be used. Allowable stresses up to 75 per cent of the failure stress would seem reasonable in many installations, with still lower stresses used when warranted by more severe loading conditions or misalignment. These maximum recommended stresses are shown by the lower line of Fig. 2.

To calculate the load-carrying capacity of continuously lubricated Zytel 101 hob-cut teeth, the following variation of the basic Lewis equation† can be used:

$$T = \frac{SDfY}{2P}$$

where T = torque to be transmitted for any given life, lb-in.; S = allowable bending stress, never exceeding the value shown by the lower line of Fig. 2, psi; D = pitch diameter, in.; f = face width, in.; Y = tooth-form factor‡ for load applied near pitch circle; and P = diametral pitch.

Load-Carrying Capacity without Lubrication: When the teeth are not lubricated after being doused initially with oil, failure takes place just below the pitch circle rather than at the root of the tooth. Continued operation after a tooth has broken tends to mutilate the adjoining teeth when no lubrication is provided.

Failure near the pitch circle may be caused by excessive surface temperatures weakening the material at this point, thus initiating a shear type of failure. Although the mechanics of this failure have not been thoroughly investigated, it is quite apparent that bending-stress calculations used with the lubricated teeth are not applicable in this case. Ratios of the torque capacity of the same teeth, with and without lubrication, is shown in Fig. 3. It will be noted that for any desired life, the torque capacity is considerably reduced when no lubrication is provided.

This information can be used with the lubricated-tooth data presented earlier to establish the

*For a description of the methods and equipment used in testing Zytel 101 nylon gears, see "Testing Gears" by H. H. Alvord and K. W. Hall, MACHINE DESIGN, July 26, 1956, Page 95.

†Originally presented by Wilfred Lewis in 1892, now found in all texts on gear design.

‡E. Buckingham—*Analytical Mechanics of Gears*, McGraw-Hill Book Co. Inc., New York, First Edition, 1949, Page 477. Published values should be multiplied by π.

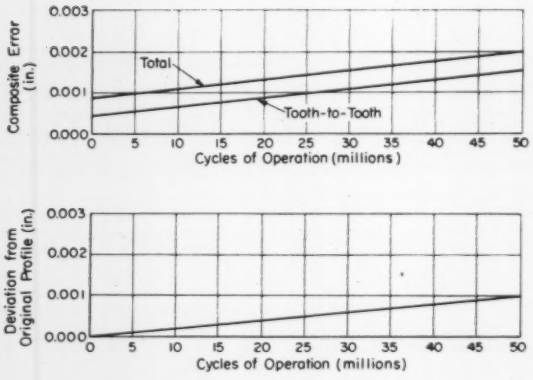


Fig. 4—Wear of lubricated 16 and 20-pitch teeth; torque, 58.8 to 117.5 lb-in.

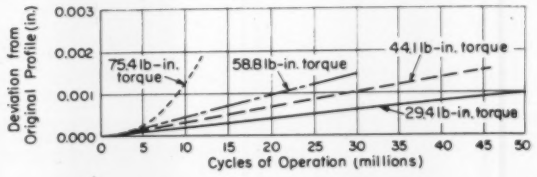


Fig. 5—Wear of nonlubricated teeth on gears operated at 2500 rpm.

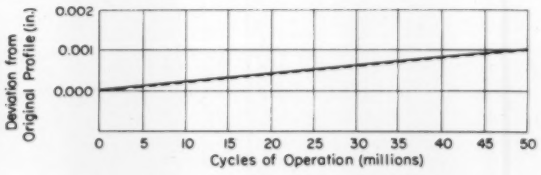


Fig. 6—Wear of lubricated and nonlubricated teeth with torque to provide equal life: 29.4 lb-in., nonlubricated; and 102.8 lb-in., lubricated; both at 2500 rpm.

load-carrying capacity of teeth that can be lubricated once prior to operation, but which are not to be lubricated thereafter.

Gear-Tooth Wear: Although the load-carrying capacity of hob-cut teeth of Zytel 101 appears to be governed by breaking strength rather than by wear, some of the information obtained on tooth wear is worth presenting. It was found that when the teeth were lubricated, the teeth wore at essentially the same rate regardless of the load, provided the tooth load was not so large as to cause bending-fatigue failure prior to about 50 million cycles. Fig. 4 shows the rate of tooth wear as measured by the change in composite error and the profile change. Since the test gears were open to the atmosphere during all the test work, it was concluded that tooth wear might be further reduced, or even eliminated completely, if the teeth were totally enclosed to keep out all foreign particles.

Without lubrication the rate of wear increased with an increase in tooth load, as shown in Fig. 5.

When transmitting torques that permit about 50 million cycles life for both the lubricated and nonlubricated conditions, tooth wear was essentially the same for both conditions. This is shown in Fig. 6, where the average tooth wear is approximately 0.001-in. for 50 million cycles of operation.

Calculated surface compressive stresses, or pressures, of approximately 5000 and 2600 psi were carried successfully for 50 million cycles by the lubricated and nonlubricated teeth, respectively, without excessive wear. These stresses were calculated by the Hertz equation for contact at the pitch point with all the load on one tooth. A modulus of elasticity of 160,000 psi at 100 F was assumed for these calculations.

Effects of Temperature and Humidity: The ambient temperature and humidity were not controlled during the test work. Temperature ranged from 68 to 92 F, while the relative humidity varied from 29 to 80 per cent. The gears were not visibly affected by these temperature and humidity changes.

One gear which had never operated was checked with the other gears at each inspection to see if the gears were dimensionally stable. Virtually no change could be noted in these control gears, indicating that the dimensional stability was not affected by day-to-day changes in temperature and humidity.

With or without lubrication, the torque lost due to friction in the teeth was small. This friction torque was about one per cent of the transmitted torque when the teeth were lubricated, and not much greater than this without lubrication.

Friction torque tends to increase as the gear teeth wear with continued operation. This tendency was more pronounced when lubrication was omitted.

Effect of Inaccuracies: Inaccuracies in tooth form and thickness caused by continued wear did not seem to affect the operation of the gears in any way, except for the tendency for the tooth friction to increase somewhat with wear. This may indicate that gears made of Zytel 101 do not need the degree of tooth accuracy required by some other materials.

From a paper entitled "Load-Carrying Capacity of Spur-Gear Teeth Hob Cut from Molded du Pont 'Zytel' 101" presented at the ASME Semi-Annual Meeting in Cleveland, June, 1956.

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Circle 559 on page 19

Designing electronic equipment for

Radio Interference Reduction

By A. L. Albin and H. M. Sachs

Armour Research Foundation of Illinois Institute of Technology Chicago

FOR EFFECTIVE application of radio-interference suppression, it is important to consider the problem early in the design stage. While considerable interference reduction can often be achieved by conservative design, additional components must frequently be incorporated in equipment to obtain the desired degree of interference reduction. Consequently, it is advantageous to anticipate possible difficulties and provide room in the equipment for such components. Furthermore, conventional parts may often be replaced by others which have superior interference - reduction properties at little or no added cost.

Sources of Interference: Undesired coupling leading to radio interference may occur by radiation, induction or conduction. Since so-called "radiated" measurements are often made in the induction field, it has become general practice to include the influence of both the near and far fields within the scope of radiated interference. Although not strictly a rigorous interpretation, it serves as a practical distinction from the mode of transmission wherein coupling occurs by means of currents propagated along circuit conductors or ground paths.

Interference generators, which may produce waveshapes of many varieties, may be grouped broadly into two general areas: broadband and continuous - wave sources. Broadband interference may be produced by pulses of short rise and decay times, which have appreciable energy content extending over a wide range of frequencies. A radar modulator, for example, produces a pulsed output signal at a fundamental repetition rate of 400 to 3000 cps, yet may contain significant energy components as high as 30 megacycles. Continuous-wave interference is that produced at discrete frequencies due to such effects as harmonics, parasitic oscillations, and other generators of primarily sinusoidal waveform.

Almost any radio transmitter can be a source of interference unless extreme care is given to control the generation of spurious emission. The need for accurate frequency control in very-high-frequency and ultrahigh-frequency communications has resulted in the use of crystal control at relatively low frequencies, followed by frequency multipliers and power amplifiers to obtain desired output characteristic. Each intermediate stage can radiate on its fundamental as well as harmonics of the output frequency. In addition, circuit resonances at frequencies removed from the operating point may result in generation of parasitic oscillations. Improperly designed or tuned transmitters may produce spurious sidebands.

A microwave radar transmitter is seldom a problem of communications since its frequency is sufficiently removed to preclude interference to receivers other than those operating in the same band, and filters can readily be applied where overloading causes spurious responses in the receivers. On the other hand, the modulator is a most prolific source of interference. The high peak powers and steep wavefronts produced by the pulsed output give rise to an extensive spectrum of spurious frequencies, as previously noted.

Not often suspected but a frequent offender is the superheterodyne receiver. Local-oscillator radiation from the antenna or chassis may be sufficient to block adjacent receivers on certain frequencies.

There are a number of other sources of interference, such as ignition systems, rotating machinery, and contacting devices.

Interference Reduction: Several preventive measures are available to the designer who is interested in obtaining equipment which is free of interference. In many cases interference-free components are available for assembly in complete units. Careful choice in component selection can do much to reduce the overall suppression engineering. When installing systems where both transmitters and receivers are used, care should be taken to avoid locating high-level interference sources, such as radar modulators or radio-frequency transmitters, in proximity to the receivers.

When the preceding measures are insufficient, there are other means of controlling interference. The primary methods by which such suppression may be accomplished are shielding and filtering. By insuring that the equipment case is of adequate thickness, the joints welded or otherwise continuous, and by providing spring-contact fingers or conducting gaskets on the periphery of removable covers or doors, the induction and radiation fields can be contained within the equipment enclosure.

To maintain shielding integrity, all lines entering or leaving the enclosure must be decoupled by suitable filters. These may consist of simple feed-through capacitors, or more complex inductance-capacitance networks. In the presence of strong radiation at a fixed frequency — such as the microwave energy from a radar transmitter — tuned filters in the receiver antenna circuits are often quite effective. It is also necessary to insure that all units are bonded to ground with a strap that offers low impedance to radio frequencies.

Summary: To summarize briefly, remedial measures for reduction of radio interference in the design of electronic equipment include:

1. Case shielding.
2. Filtering of input and output leads.
3. Good rf bonds.
4. Conservative design.

From a paper entitled "Design of Electronic Equipment for Radio Interference Reduction" presented at the AIEE Winter General Meeting in New York, January-February, 1956.

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For copies of any literature listed, circle number on Yellow Card—page 19

Precision Steel Tubing

"Fluid-Power Steel Tubing" is a buyers' and designers' guide to Rockrite steel tubing and cold finished steel bars for hydraulic cylinders and fluid lines. Engineering data are given in bulletin 12-6. 8 pages. Joseph T. Ryerson & Son, Inc.

Circle 401 on page 19

High Temperature Terminals

Details, dimensions and properties of AlSiMag high temperature hermetic terminals for electrical and electronic equipment are subject of illustrated bulletin 553. Standard and custom terminals are available. 2 pages. American Lava Corp.

Circle 402 on page 19

Alloy Iron Castings

"Moly Iron Castings" is the title of a series of bulletins which will present technical information and case histories on the use of molybdenum as an alloying element in gray iron castings. Bulletins 1 and 2 are now available. 4 pages each. Climax Molybdenum Co.

Circle 403 on page 19

Pressure Lubricators

Automatic lubricators featuring a newly designed constant-feed rotary pump are described in technical data sheet No. 55C. They are suited for automatic and continuous lubrication of machines with precision ways and other equipment. 2 pages. Bijur Lubricating Corp.

Circle 404 on page 19

Variable Transformers

Details of the redesigned line of Adjust-A-Volt variable transformers in auto, isolated and metered models for bench and panel mounting are presented in catalog No. A56. They provide any output from zero to 17 per cent above line voltage. 22 pages. Standard Electrical Products Co.

Circle 405 on page 19

Teflon Hook-Up Wires

Permacode hook-up wires for permanent, positive identification have the color extruded throughout the Teflon insulation. Fifteen solid colors and two, three and four-stripe color combinations are available. Data are given in bulletin 1901. 2 pages. Revere Corp. of America.

Circle 406 on page 19

Copper Alloy Shell Molding

"The Shell Mold Process as Applied to Copper Base Alloy Castings" is descriptively covered in folder of this title. Practically any copper base alloy can be cast by this process and part tolerances from ±0.005 to 0.015-in. can be held. 6 pages. Aurora Metal Co.

Circle 407 on page 19

Low Nickel Stainless Steels

Part of a technical studies series, booklet "The Chromium-Nickel-Manganese Austenitic Stainless Steels" gives details on the 200 series low nickel, high performance stainless steels. 10 pages. Allegheny Ludlum Steel Corp.

Circle 408 on page 19

Recording Oscillograph

Photographic-type 5-117 recording oscillograph affords precision recording of six data traces at frequencies from 0-300 cps. This instrument is subject of descriptive bulletin 1533-B which points up features. Oscillograph will record almost any phenomena convertible to electrical signals. 4 pages. Consolidated Electrodynamics Corp.

Circle 409 on page 19

Machine Tool Limit Switches

Nineteen contact arrangements available with seven Denison Loxswitch models are described in bulletin 356 on machine tool limit switches. Brochure shows heavy duty oil and water-tight models which meet NEMA 12 specification. 4 pages. R. B. Denison Mfg. Co.

Circle 410 on page 19

Bronze Bearing Stock List

Stock list S-56 gives dimensions of about 1050 different Oilite sleeve, flange and thrust bearings ranging in size from ⅛ to 4 in. ID. Included is a substantial selection of cored, bar and plate stock, plus six pages of engineering data. Bearings are impregnated with about 20 per cent by volume of oil which lubricates and absorbs shock. 20 pages. Chrysler Corp., Amplex Div.

Circle 411 on page 19

Ball Screws

How to apply the ball screw method of torque-thrust conversion to the actuation problem is told in folder "Beaver Ball Screws." Ball screws are made in $\frac{5}{16}$ to 6 in. sizes in load ratings from 675 to 125,000 lb and torques from 12 to 17,700 lb-in. 4 pages. Beaver Precision Products, Inc.

Circle 412 on page 19

Electric Furnace Iron

A gray iron of precisely controlled properties in unalloyed and alloyed grades is described in bulletin "Belectric Iron," No. 15 of a series. Physical properties of these two grades are tabulated. 4 pages. Belle City Malleable Iron Co.

Circle 413 on page 19

Belts, Packing, Seals

"Engineers, Designers, Manufacturers" is title of brochure which describes custom molded natural and synthetic rubber products, belting and hydraulic and pneumatic packings, and shaft and face sealing materials. 16 pages. Chicago-Allis Mfg. Corp.

Circle 414 on page 19

Centrifugal Process Pumps

Standard centrifugal process pumps for industrial, refinery and general service are offered in capacities from 10 to 7000 gpm at heads from 25 to 400 ft. Circular 184 features sectional views and parts lists, illustrates pump ranges and describes units for pumping slurries. 12 pages. Dean Brothers Pumps Inc.

Circle 415 on page 19

Small Tube Forming

Twenty-five parts illustrated in folder D-51 show the wide range of diameters and sharp radii to which tubing can be bent without flattening. Tubular parts are made in a variety of metals. 4 pages. Eldon Mfg. & Engineering Co.

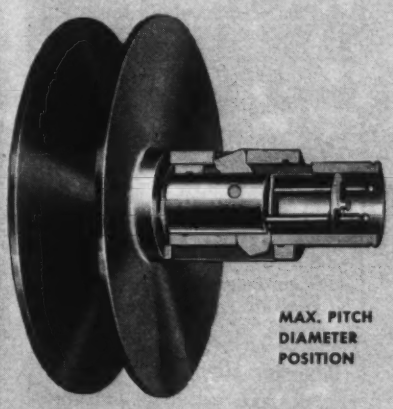
Circle 416 on page 19

Facts About Neoprene

Facts about neoprene for the engineer are provided in "Neoprene Notebook" No. 68. Issue points up neoprene's advantages in high tem-

FIRST IN PULLEY DESIGN!

Free ALL limitations with LEWELLEN VARIABLE PULLEYS COMBINATION PULLEYS



MAX. PITCH DIAMETER POSITION

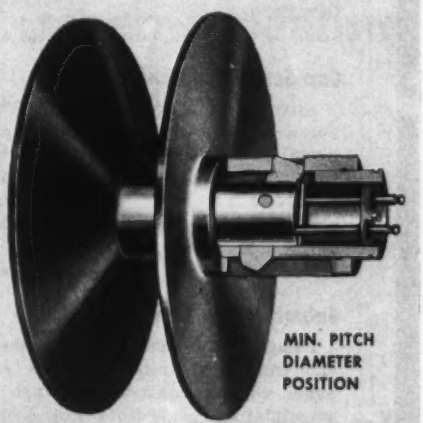
LEWELLEN DESIGN

These cut-aways show the basic Pulley. Add spring and covers to make the self-VARIABLE PULLEY. Add paired ball bearings and housings to make the manually-ADJUSTABLE PULLEY.

The sleeve, bored for motor shaft, mounts the pair of discs with their slotted hubs. The pivoted, contoured key both rotates and positions the discs.

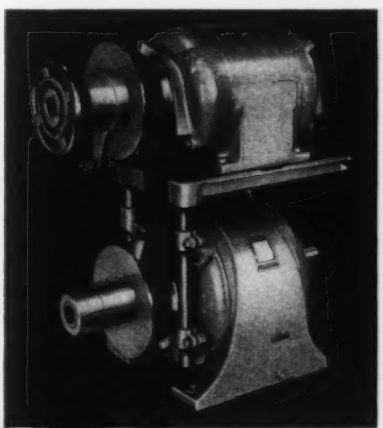
The spring—or ball bearings—independently thrust the discs, directly and equally, in driving engagement with the Variable Belt.

Each disc is separately lubricated through vented channels.



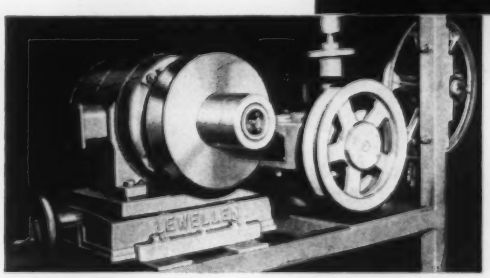
MIN. PITCH DIAMETER POSITION

Operate in any position – horizontal or vertical – up or down . . . Motor and machine shaft may point in the same or opposite directions . . . Your shafts mount the Pulleys – no supporting bracket required . . . Infinitely variable speeds are directly applied and conveniently controlled – performance is smooth, dependable . . . Loading of Pulleys is self contained – no thrust load on motor or machine shaft bearings . . . Pulley discs are symetrically, positively positioned – Variable Belt tracks in true alignment, without skew or offset, and with full traction for all speeds . . . Fixed path of Variable Belt permits driving to flat or crowned pulley, or to sheave.



Lewellen Combination Pulleys with Foote Vari-Mount Reducer and standard motor. Standard components comprise an accessible, compact, motorized variable-speed unit.

Lewellen Variable Pulley and Adjustable Base incorporated with Fowler-Minder Filler Machine, manufactured by Quality Machine Co.

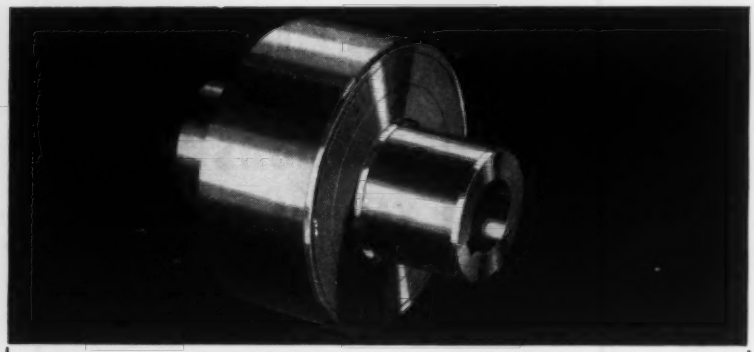


WRITE FOR CATALOG NO. 60-A
Complete new section on combination pulleys

LEWELLEN MANUFACTURING CO. COLUMBUS, INDIANA

Distributors In All Industrial Areas • In Canada – Peerless Engineering Sales Ltd. Toronto – Montreal

Circle 560 on page 19



Rawson Automatic Centrifugal Clutch

SAVINGS — on initial and replacement equipment costs through:—

Normal torque standard squirrel cage motors instead of special high torque motors

Smaller motors since same HP requirements are used for starting as for running

Elimination of expensive electrical starting equipment

Reduced electrical starting surges and peak demands

Standard applications to 1000 HP

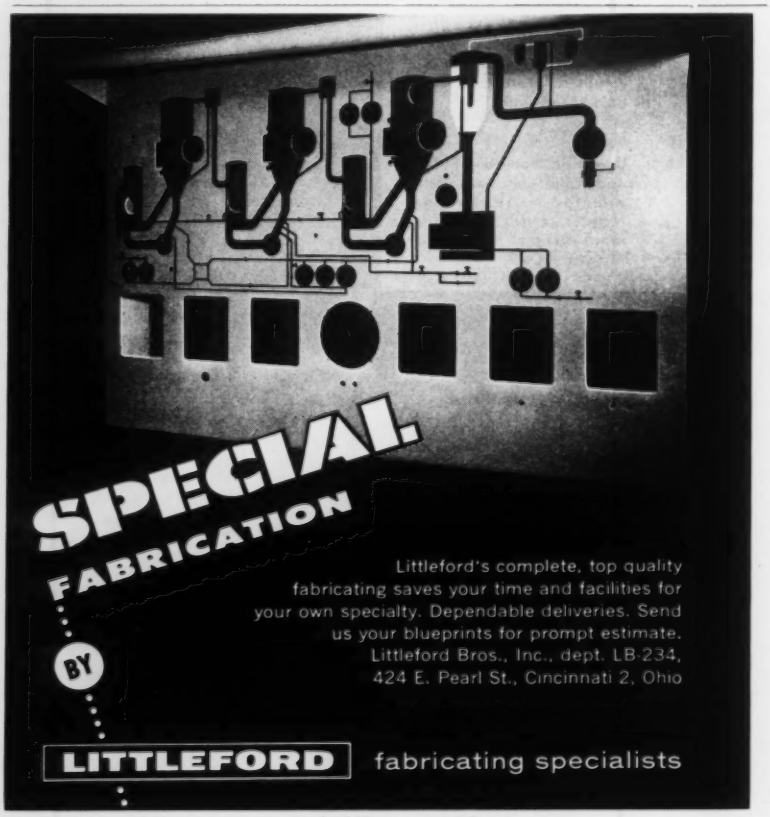
Better motor efficiency, better power factor

RAWSON COUPLINGS

O. S. WALKER COMPANY, INC.

400 Rockdale St. • Worcester, Mass.

Circle 561 on page 19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Littleford's complete, top quality fabricating saves your time and facilities for your own specialty. Dependable deliveries. Send us your blueprints for prompt estimate.
Littleford Bros., Inc., dept. LB-234, 424 E. Pearl St., Cincinnati 2, Ohio
LITTLEFORD
fabricating specialists

Circle 562 on page 19

Helpful Literature

perature uses, as a seal, as industrial truck tires, conveyor belting, protecting buried electrical equipment, clutch and brake material and other applications. 8 pages. E. I. du Pont de Nemours & Co., Elastomers Div.

—Circle ITEM 417

Brazing & Welding Rod

Low-fuming, high-strength Ampco-Braz No. 1 "3-in-1" filler rod, a versatile nickel-brass rod for brazing and braze-welding with oxy-acetylene, is subject of bulletin W-31. Sections cover rod's uses in industry and small shops and describe characteristics, deposit mechanical properties, application and sizes. Ampco Metal, Inc.

—Circle ITEM 418

Capsular Elements

A large selection of Ni-Span C capsular elements for the aircraft and instrument industries are announced in bulletin AV2001. Data will aid designer in selecting and assembling the proper component for specific applications. Bristol Co.

—Circle ITEM 419

Pneumatic Operators

Butterfly valves, gas and oil burner valves, and dampers are typical of the components that can be actuated with pneumatic spring and diaphragm Conomotors described in bulletin B-1020-5. These operators are available from the factory in complete valve assemblies. 4 pages. Conoflow Corp.

—Circle ITEM 420

Cap Screw Tightening

Answers to the question "Cap Screws . . . How Much Torque?" are given in engineering bulletin of this title. Tables list torques for various sizes and types of cap screws and place bolts. 4 pages. Cleveland Cap Screw Co.

—Circle ITEM 421

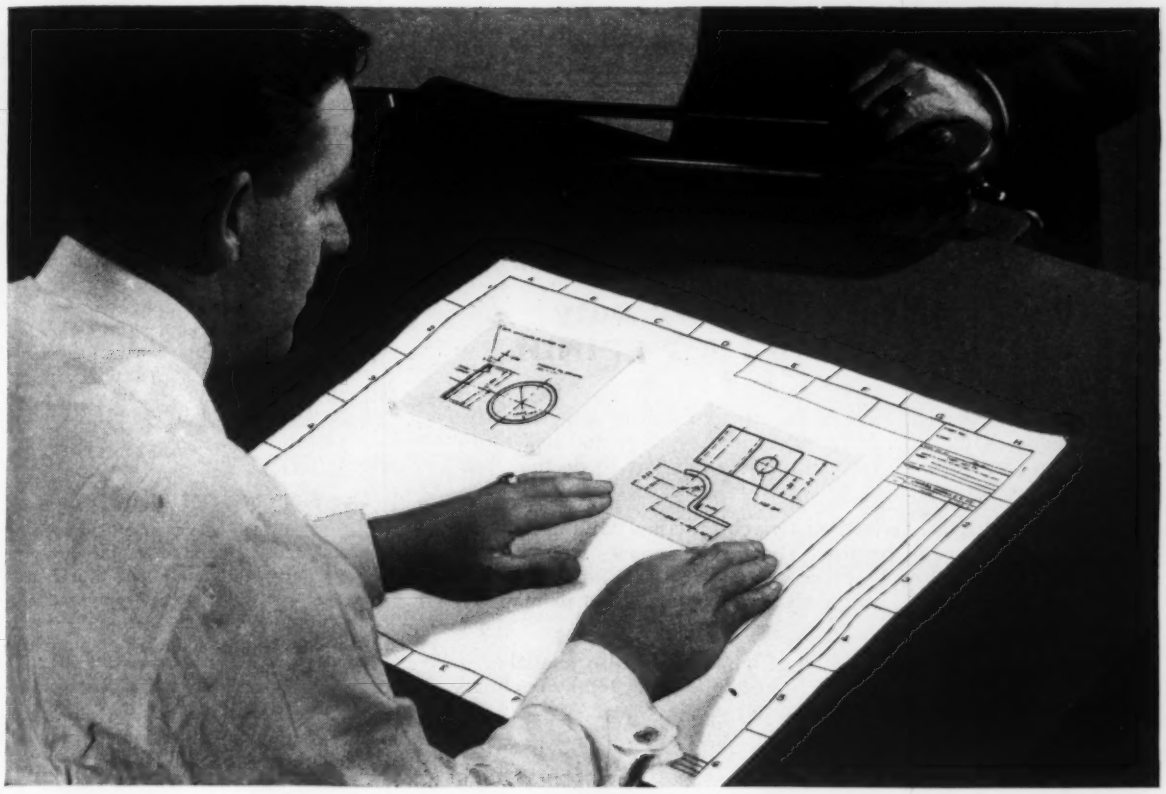
Subminiature Connectors

Designed for miniature equipment and components requiring rack and panel chassis construction, type D subminiature connectors are usable in electronic, radio, aviation, instrument and other fields. Dimensions and performance data are listed. 8 pages. Cannon Electric Co.

—Circle ITEM 422

Teflon Products

Tapes, sheets, rods, tubes, gaskets and fabricated specialties made of Teflon are cataloged in bulletin T-55. Design data given includes applications, comparative properties, engi-



To save hours of redrafting when repeating designs

BY USING low-cost photo-templates of your standard designs—made on Kodak Autopositive Film Thin Base—you can combine or build up drawings as easily as this:

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New booklet is jam-packed with valuable tips on saving drafting time, protecting drawings, getting better prints.

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Graphic Reproduction Division, Rochester 4, N. Y.
Gentlemen: Please send me a free copy of your new booklet on Kodagraph Reproduction Materials.

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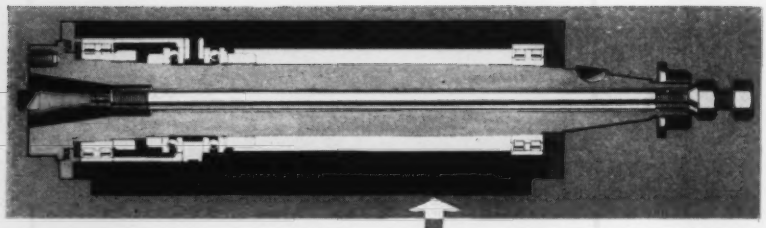
Kodak



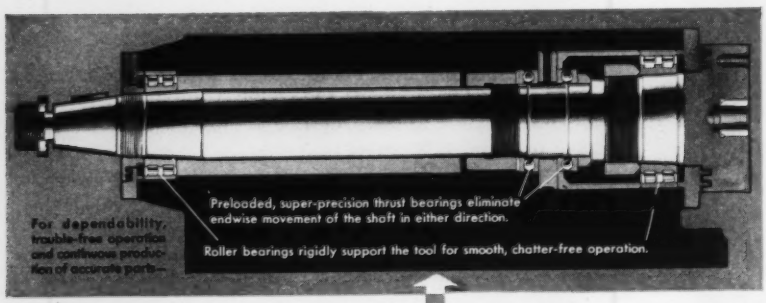
PRECISION MILLING calls for this

POPE Heavy Duty **MILLING SPINDLE**

See for yourself! Here is one sturdy package with a massive shaft, and double row cylindrical roller bearings and ball thrust bearings that support your cutting tools rigidly to do their best work.

POPE P-12000 Series Belt Driven Precision Milling Spindles are operable in any position. They come in sizes from 1 to 50 HP with standard milling machine tapers in the nose from #10 to #60. Bulletin S-8 gives complete dimensions. Let us mail you a copy.

POPE Heavy Duty Milling Spindles are also available in P-2500 Series, MOTORIZED, from 1 to 100 HP, totally enclosed, fan cooled; and in high cycle, water cooled units.


Preloaded, super-precision thrust bearings eliminate endwise movement of the shaft in either direction.
For dependability, trouble-free operation and continuous production of accurate parts—
Roller bearings rigidly support the tool for smooth, chatter-free operation.

PRECISION BORING calls for this

POPE Heavy Duty **BORING SPINDLE**

Look it over! Here is a Boring Spindle capable of boring holes round within *millionths of an inch.* It produces fine surface finishes in the lower micro inch range.

POPE Super-Precision Heavy Duty Boring Spindles are available in both belt driven and motorized units to meet a wide range of speeds and horsepower. Send us your specifications for quotations.

Pope designs, engineers and builds SPECIAL SPINDLES

No. 112

Specify **POPE** PRECISION SPINDLES

POPE MACHINERY CORPORATION
Established 1920
261 RIVER STREET • HAVERHILL, MASSACHUSETTS

Circle 564 on page 19

Helpful Literature

neering services, fabrication, grade descriptions, machining information and details of copper-clad stock. 16 pages. Budd Co., Continental-Diamond Fibre Div.

Circle 423 on page 19

Thermocouples & Parts

In addition to describing a complete line of thermocouple assemblies and pressure sealing glands, catalog 1556 introduces new check wells, Speedwells, multiple wire thermocouple glands, pressure sealing spring loaded thermocouples and Flex-tube assemblies. 28 pages. Conax Corp.

Circle 424 on page 19

Low Melting-Point Alloys

Sixty-three known useful applications, mostly in the metalworking field, are tabulated in illustrated folder on Cerro low-temperature-melting alloys. Classifications covered are design in anchoring nonmoving parts in machinery, pattern and model reproduction, punch and die anchorage, and holding work pieces of thin or irregular section. 4 pages. Cerro de Pasco Corp.

Circle 425 on page 19

Stainless Spring Wire

Specifications of Blue Label type 302 stainless wire for springs and similar parts are presented in bulletin. Tensile strength, resistance to relaxation at elevated temperatures, shapes and sizes are covered. 2 pages. Carpenter Steel Co., Webb Wire Div.

Circle 426 on page 19

Snap-Action Thermostats

Physical, electrical and performance specifications for various types of snap-action, locally adjustable thermostats are found in illustrated catalog MC-120B. Six temperature ranges, four head types, six "application rated" switches and two mounting styles are included. 4 pages. Fenwal Inc.

Circle 427 on page 19

Transformers

How voltage stabilizing transformers provide stable voltage is related in illustrated bulletin GED-2987. Features, advantages, selection guide and application and specification chart are included. 12 pages. General Electric Co.

Circle 428 on page 19

Liquid Level System

Liquid level sensing system described in booklet AD-404 is capable of operating a lamp to indicate that

When steel is 3 times stronger than iron . . .

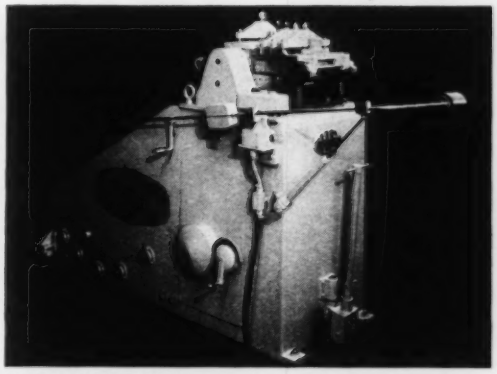
Has two and one-half times the rigidity . . .

Yet costs a third as much per pound . . .

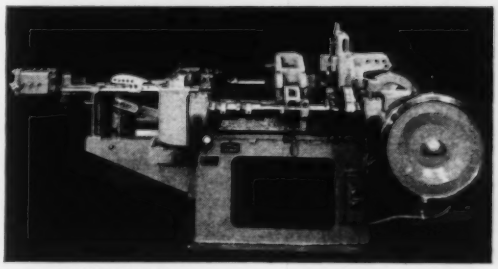
WHY

aren't more of your products designed for welded steel?

Photos courtesy U. S. Tool Company, Inc., Ampere, New Jersey.



Present welded steel design.



Present welded steel design.

Cuts high replacement costs... after switching to welded bases

AFTER casting failures resulted in expensive replacement costs, this machine tool manufacturer converted his base designs to welded steel. Bases are now practically breakproof. Greater uniformity in dimensions saves time in locating parts in jigs. Appearance is greatly improved.

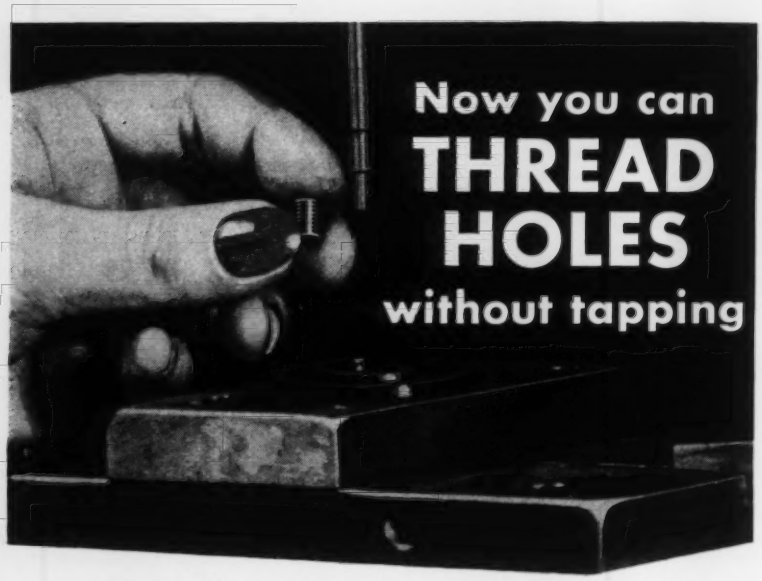
Lincoln can show you how to convert your designs to welded steel for similar savings and benefits. Write us today.

THE LINCOLN ELECTRIC COMPANY

Dept. 1115 Cleveland 17, Ohio

Creating lower costs for industry ... with welded steel

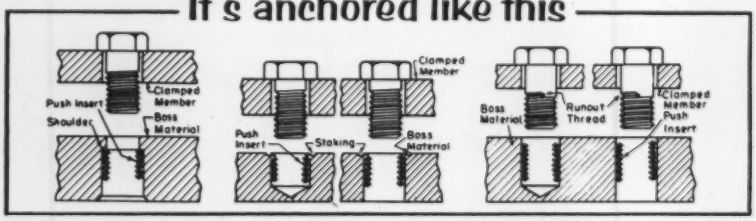
Circle 565 on page 19



New *Heli-Coil** Push Inserts offer ready-made female threads for your product at an overall cost of less than one cent per hole *installed!* Tooling for their use is simple—simply a special mandrel, no more complicated than a drill, which can be used in a drill press, kick press, or any similar device of suitable stroke to push the insert into drilled, cast, or molded through or blind holes.

This new method of threading is ideal for lightly stressed assemblies of molded plastic, powdered metals, die castings, and other soft or hard materials where there is high-volume production. No more tapping, no more molding-in solid bushings.

It looks like this--
It's anchored like this



CAN YOU ENJOY THESE SAVINGS?

Send coupon now for Bulletin and "Design Application Chart," a simple questionnaire which, when filled in, will enable us to tell you whether the *Heli-Coil* Push Type Insert is practical for the application you have in mind.

*Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
129 Shelter Rock Lane, Danbury, Conn.

- ☐ Send Standard Push Insert Application Chart and bulletin on this new technique.
- ☐ Send design data on *Heli-Coil* Screw Thread Inserts.
- ☐ Send design data on *Heli-Coil* Screw Lock (Mid-Grip) Inserts.

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

3543

HELI-COIL CORPORATION: Manufacturer of *Heli-Coil* Screw Thread Inserts, *Heli-Coil* Screw Lock Inserts and *Heli-Coil* Push Inserts.

IN CANADA: W. R. Watkins Co., Ltd., 41 Kipling Ave. So., Toronto 18, Ont.

Circle 566 on page 19

Helpful Literature

a liquid is above or below a certain level. It can also control pump operation or operate valves to transfer liquids. System details are given. 8 pages. Simmonds Aerocessories, Inc.

—Circle ITEM 429

Welding Electrodes

Method of application, properties of deposited metals, procedures and typical applications of electrodes are covered in detail in the "Lincoln Weldirectory." Bulletin SB-1352 includes many types of electrodes for stainless steel, nonferrous metals, cast iron and hard surfacing. 28 pages. Lincoln Electric Co.

—Circle ITEM 430

Printed Circuit Connectors

Expanded line of printed circuit receptacles for $\frac{1}{16}$, $\frac{1}{32}$ and $\frac{1}{8}$-in. boards are covered in illustrated technical brochure. Outline drawings and application suggestions are included for 6 to 28-contact units. 12 pages. DeJur-Amsco Corp.

—Circle ITEM 431

Speed Control Systems

A number of ways in which automated speed control is used to maintain constant velocity feeding and winding, variable rate proportioning, punch card product blending, etc., are described in bulletin C-100. Graham variable speed drives can be controlled automatically from any leading make recorder from zero to any top speed. 4 pages. Graham Transmissions Inc.

—Circle ITEM 432

Cemented Carbides

Mechanical information required by engineers who design parts calling for Kennametal cemented carbides is contained in booklet B-222, "Designing with Kennametal." Methods of forming and fastening, mountings and many typical applications are detailed. Numerous line drawings are included. 40 pages. Kennametal Inc.

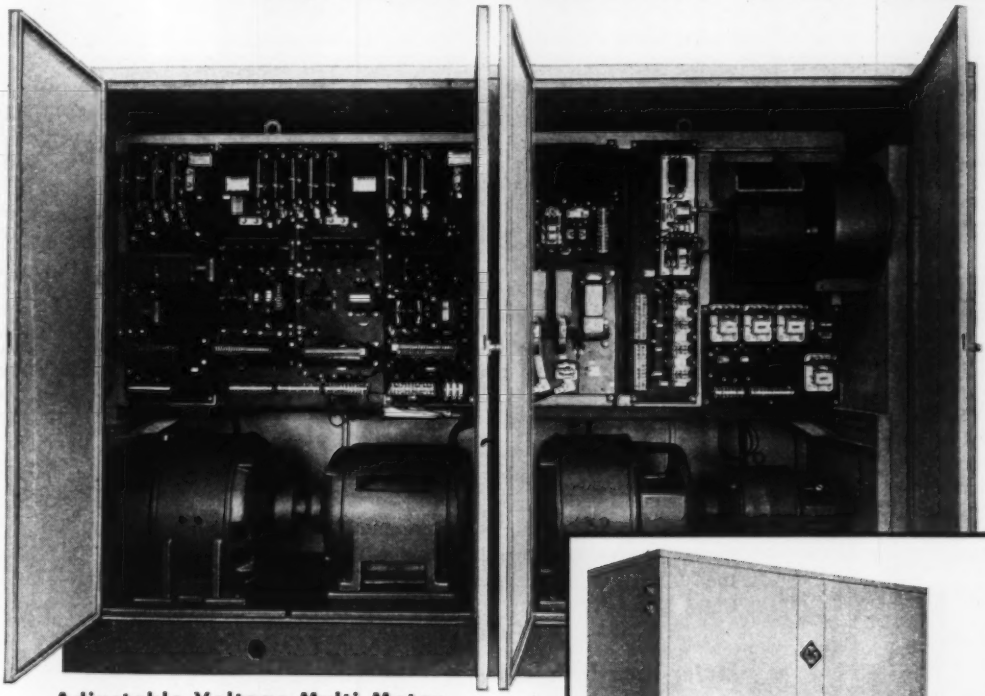
—Circle ITEM 433

Fluid Power Valves

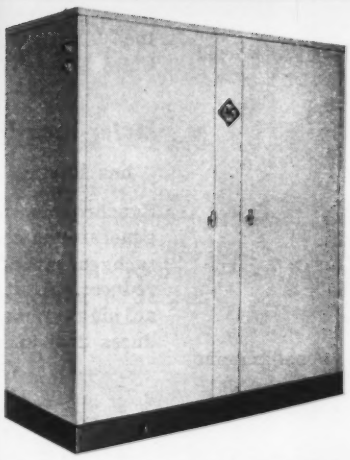
Performance data, capacities, types, sizes and mounting dimensions comprise the factual information provided in catalog H-12 on "performance rated" oil hydraulic valves. Valves feature reduced resistance to flow, have discharge ratings to 55 gpm and operate on pressures up to 2000 psi. For your copy of this 92-page catalog, write on company letterhead to H. S. Thompson, Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown 1, O.

There's MORE dependable speed control

- high response
- high shock resistance
- no fragile parts
- no maintenance



Adjustable Voltage Multi-Motor Package Drive used with heat flattening and coating equipment. Unit features magnetic amplifier control of tension and strip speed.



Size 3 Adjustable Voltage Power Unit rated 30 hp, of standard construction. Magnetic amplifier excitation provided.

Every one of the design features of the Allis-Chalmers Adjustable Voltage Package Drive assures you an easy, dependable means of power conversion.

Key to Package Drive dependability is the use of a magnetic amplifier to excite the field of the power unit m-g set. Sturdy and simple, this amplifier has no moving parts to wear out . . . no fragile components to be affected by vibrations. AND — there's no wasteful "warm-up" time needed. At the turn of a dial, you get immediate speed control.

Cost-saving assembly

M-g set and control components are assembled in the power unit enclosure at the factory — saving you installation costs. Enclosures used for 30 through 200-hp units are completely collapsible and may be easily disassembled without loss of rigidity. Larger units have separately driven blowers to provide positive ventilation and pressure even when unit is idle.

Available in units from 5 to 200 hp, the package drive is ideal for any application requiring adjustable speed. Contact your nearby Allis-Chalmers sales office or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5166

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Centrifugal Clutch

utilizes wedging action of tapered studs

A clutch designed for use with small high-starting torque motors is engaged by both centrifugal force and an angular wedging action. As centrifugal force moves the shoes out, pressure is intensified by the wedging action of the taper pins over which the shoes are mounted. Speeds are accurately predetermined as both shoes engage simultaneously with equal pressures against the drum walls. Engagement speeds are changed by using springs with different tension. With the shoes not anchored solidly, a float of 4 deg is allowed

to compensate for misalignment when the clutch is used as a coupling. **E-Z Machine & Tool Works,** Beloit, Wis.

Circle 451 on page 19

Potentiometer

is subminiature high-temperature unit

High temperature precision potentiometer, rated to 200 C, is a high-power, servomount, subminiature, single-turn, rotary unit with power rating of 2 w at 150 C. Coil and wiper utilize precious metals to permit low contact pressure and provide long, noise-free life. Po-

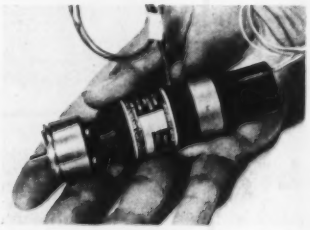
tentiometer, ⅞-in. diam, has linearity of ±0.5 per cent minimum, resolution up to 0.06 per cent. It may be supplied with taps, and as many as six sections can be ganged on a single shaft. The model 875T has precision ground stainless-steel shaft, ball-bearing mounted, and machined, anodized aluminum housing. **G. M. Giannini & Co. Inc.,** 918 E. Green St., Pasadena 1, Calif.

Circle 452 on page 19

Motor-Tach Generator

has integral gear reducer

Synchronous motor - tachometer generator is combination of motor, tachgenerator, and 3:1 spur gear reducer. Unit operates at 115 v ac, single phase, 400 cps, and produces 2 oz-in. torque at 4000 rpm

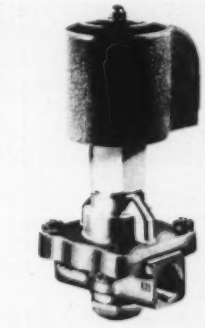


at output shaft. Generator is two-phase, sine wave output design producing 20 v per phase at 200 cps, with harmonic content normally less than 5 per cent. Generator output can be 400, 200, or 133 1/3 cps at various voltages, and unit is available with other ratios on speed reducer. Weight is 12 to 16 oz, depending on speed ratio. Meeting environmental requirements of MIL - M - 7969A (ASG), uses for unit are in servo systems, or as a drive in mechanical sweep systems requiring two-phase follow-up. **Globe Industries Inc.,** 1784 Stanley Ave., Dayton 4, O.

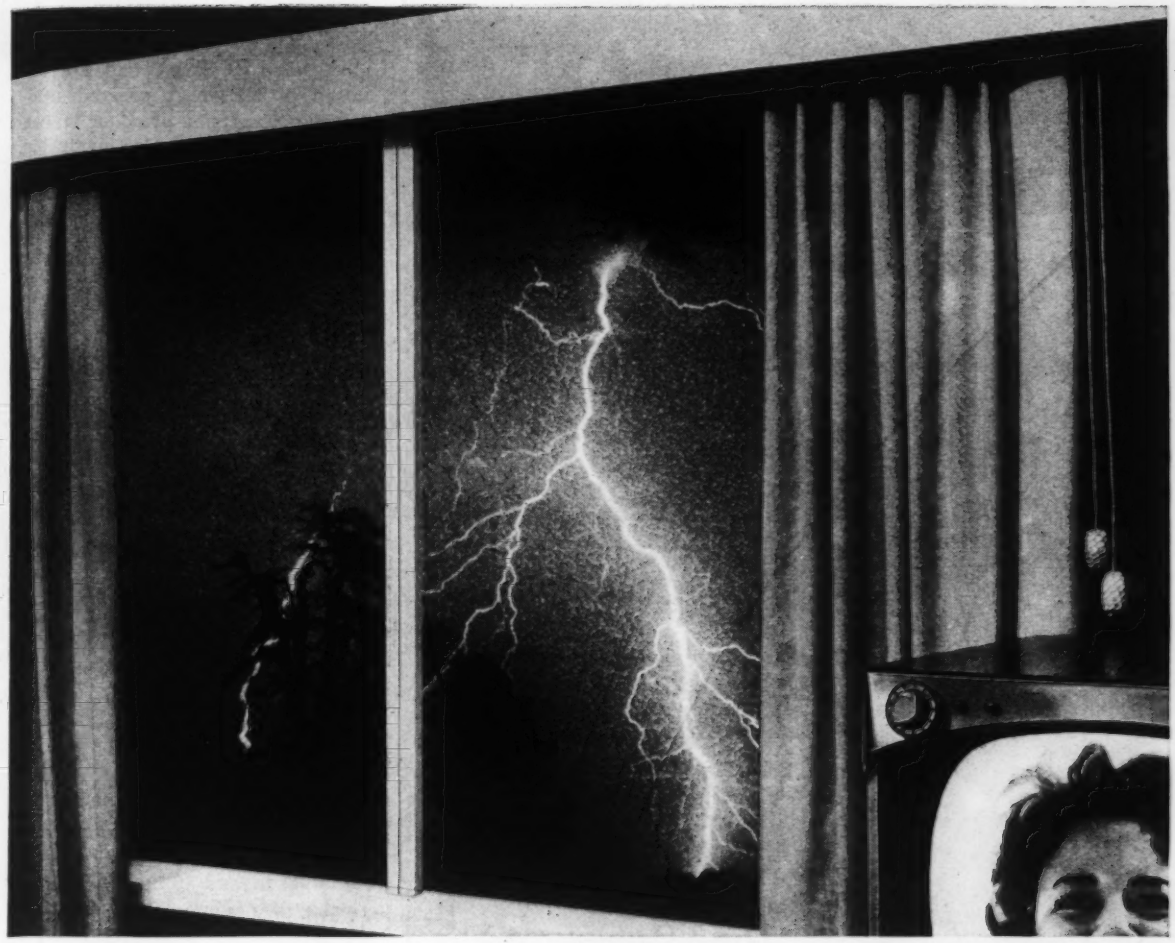
Circle 453 on page 19

Solenoid Valve

for high-pressure heavy fuel oil



Pilot-operated solenoid valve for high pressure, heavy fuel oil has packless, two-way bronze body, with full ¾-in. port, and pressure range of 15 to 300 psi. Fuel oil temperature may be up to 200 F. Internal piston is located on downstream side of valve, provides more pressure than necessary to open valve, and allows usage of very strong closing spring. Valve is normally closed and gives absolute tight shut-off at all oil pressures. Bottom cap may be removed to inspect and clean disk assembly without disassembly of valve or removal from line. Solenoid coils are continuous duty class H insulated, high tempera-



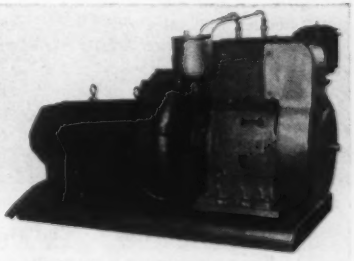
Leland generators guard the air waves

Keeping communication channels open despite failure of normal power is but one of the *many* jobs dependable Leland generators have been doing for years.

Take remotely located micro-wave relay stations that are often at the mercy of the elements. They must *unfailingly* "beam" the signal through . . . to brighten your home with TV. . . provide State Police communications . . . control many vital operations from commercial pipelines to national defense warning systems.

Rugged Leland generators, in special electric/gas-driven power units, regulate the normal power supply day in and year out . . . *take over completely and automatically* the instant normal power fails . . . provide uninterrupted service. With Leland generators in the system there's never a moment's delay.

A soundly engineered Leland unit is a safe bet to make *your* product better. Investigate Leland generators . . . and complete line of motors from ⅛ through 5 hp, soon to 20 hp, in all popular types and enclosures. Write today.



Developing 5 KW, a dependable Leland motor-alternator is a major component of this special "Micro-Power" unit designed for all communications services.

Another AMF Product

LELAND MOTORS

THE LELAND ELECTRIC COMPANY

Dayton 1, Ohio

Division of AMERICAN MACHINE & FOUNDRY COMPANY

Circle 568 on page 19

XUM

Comfort...

NEEDS LUBRICATION, TOO!

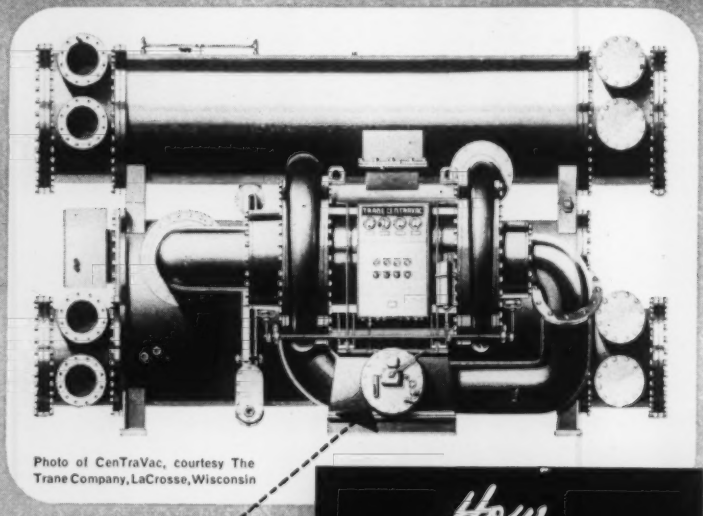
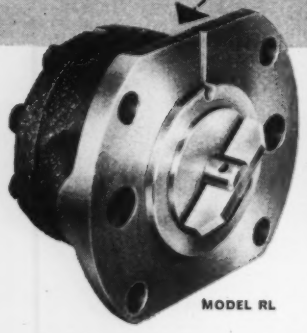


Photo of CenTraVac, courtesy The Trane Company, LaCrosse, Wisconsin



MODEL RL

How

TUTHILL PUMPS Help the Trane "CenTraVac" Keep Customers Cool

In developing the unique CenTraVac hermetic centrifugal refrigeration unit, Trane engineers required a positive lubrication system that would be both simple and foolproof. For the heart of this system, they selected the Tuthill Model RL—a positive displacement, internal-gear rotary pump with automatic reversing feature.

The performance characteristics of this pumping unit make it most dependable for pressure lubrication service. Model RL holds its prime and delivers the capacity needed instantly—a "must" in the CenTraVac, since full oil pressure must be developed before the unit will start—let alone operate.

Quiet in operation—also a "must" in CenTraVac—Model RL is built for long, uninterrupted service. Its automatic reversing feature offers further insurance of positive lubrication, since the pump will deliver from the same port regardless of ultimate direction of shaft rotation.

Whether you need standard or special pumps for lubrication, coolant, hydraulic, or liquid transfer service, you are invited to submit your specifications for recommendations.

Write for catalog data on Tuthill pumps for your specific needs.

See our catalog in Sweet's Product Design File—6b-Tu

TUTHILL PUMP COMPANY

Dependable Rotary Pumps . . . since 1927

939 East 95th Street, Chicago 19, Illinois

Canadian Affiliate: Ingersoll Machine & Tool Co., Ltd., Ingersoll, Ontario, Canada

Circle 569 on page 19

New Parts

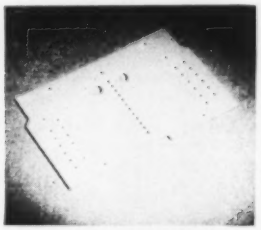
ture, rated 31 w ac, and are enclosed in NEMA 1 pressed steel housing. Explosion-proof or watertight housings are also available. **Automatic Switch Co.,** 391 Lakeside Ave., Orange, N. J.

Circle 454 on page 19

Paper-Base Laminate

has high arc and flame resistance

Phenolite Y-2500 is a paper-base laminate bonded with a modified phenolic resin which is flame-resistant; the material is self-extinguishing within 5 seconds after withdrawal of 10-second flame. Material corresponds to NEMA Grade XX, provides arc resistance up to

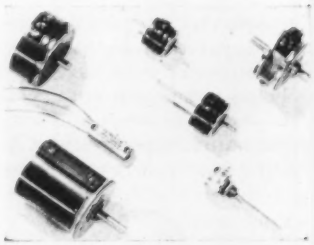


100 seconds, and is easy to punch and shave. Available in sizes of 39 by 39 in. and 39 by 47-in., sheet thicknesses range from 0.015 to 1.0 in., and colors are light brown or red, semi-gloss or dull. Laminate is suited for arc deflectors, circuit-breaker components, electrical switches, etc. **National Vulcanized Fibre Co.,** 1056 Beech St., Wilmington 99, Del.

Circle 455 on page 19

High-Temperature Pots

withstand temperatures as high as 225 C



Designed for use at high ambient temperatures, these precision potentiometers, including wire-wound and film-resistance types, have

"FOUR!"

Four? **That's right. Look closely, you'll notice this little golfer represents all four of the services available to designers from Sylvania's Parts Division: (1) Custom-molded plastics; (2) Plated, clad and alloy wire; (3) Metal stampings; (4) Electronic components.**

All of these parts were supplied in quantity to just one major manufacturer during the past year. On many of these items, Sylvania representatives were called in for consultation before parts designs were finalized. Suggestions from an experienced parts producer can often reduce costs, increase efficiency, and assure more uniform production in high volume items.

Manufacturers who insist on the highest degree of quality and efficiency can find Sylvania's 4-way service extremely helpful. For complete details write for the "Portfolio of 4-way Service to Designers." Address Dept. J52S.

SYLVANIA PARTS DIVISION

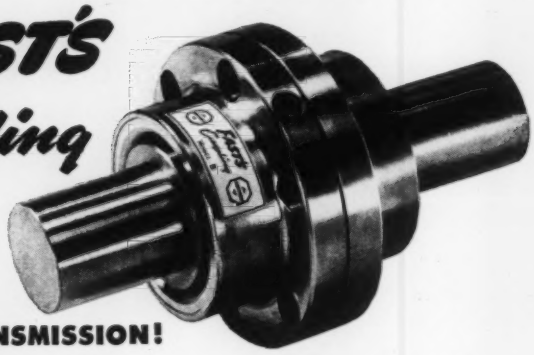
Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS

4-way service from one source

The incomparable Model B

FAST'S Coupling



LOW-COST POWER TRANSMISSION!

Designed for light and medium drives—fans, blowers, pumps—a lighter, smaller and lower priced Fast's Coupling! The same famous features found in all Fast's Couplings . . . the same mechanical flexibility, the same positive lubricating principle, the same rugged construction and trouble-free performance . . . the same highly efficient power transmission which has made Fast's Couplings the leader for more than 30 years! Available for shaft sizes up to 2⅞" and sold with Koppers' free engineering service. For the low-cost solution to your shaft coupling problem, write: Koppers Company, Inc., *Fast's Coupling Dept.*, 3509 Scott Street, Baltimore 3, Md.

THE ORIGINAL FAST'S Couplings

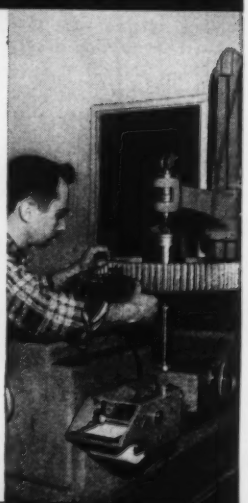
KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus. *Engineered* Products Sold with *Service*.

Circle 571 on page 19

Another of the Reasons Behind Brad Foote Quality—

TOOTH SPACING



• 99% of gear drawings do not specify tooth spacing. For most applications, industry generally believes that competent gear manufacturers, working by standard AGMA practices, will produce gears within the limitations required for easy assembly and good load transmission.

• Occasionally, however, on very precise jobs you may find it necessary to specify extreme accuracy of tooth spacing and nonadjacent tooth spacing. Applications such as radar mounts, timing mechanisms, indexing mechanisms—all may require closer tooth spacing tolerances than are obtainable with average equipment in the hands of regular gear manufacturers.

• BRAD FOOTE welcomes precision jobs like these. We can add to highly specialized equipment specific experience in meeting this, as well as many other demanding requirements for special gear production.

• Prove to yourselves the savings that BRAD FOOTE quality can mean. Let us quote on the gear requirements for your next program.

BRAD FOOTE MAKES ALL TYPES OF GEARS—IN A COMPLETE RANGE OF STYLES AND SIZES

BRAD FOOTE GEAR WORKS, INC.

1309 South Cicero Avenue • Cicero 50, Illinois

Bishop 2-1070 • OLympic 2-7700 • TWX CIC 2856-U

subsidiaries: AMERICAN GEAR & MFG. CO. Lemont, Illinois Phone Lemont 920 • PITTSBURGH GEAR COMPANY Phone SPalding 1-8400 Pittsburgh 25, Penn.

Circle 572 on page 19

New Parts

load life up to at least 500 hr and rotational life to 500,000 cycles. Wire-wound units, in both single and multiturn models are rated ¾ to 4 w, continuous duty at 125 C; rating is 0.1-w or more at 150 C, depending on size and type. Rotary Filmpots and trimmer Filmpots employ precious-metal film-resistance elements. Rotary types are ¾ to 1⅛ in. diam and are rated at 225 C for the ¾-in. unit, 150 C for the larger units. Trimmer pots are rated to 175 C. **Fairchild Controls Corp.**, Components Div., 225 Park Ave., Hicksville, N. Y.

Circle 456 on page 19

Relief Valve

for temperatures to 650 F

In-line airborne relief valve for oil-hydraulic service delivers flow at 2300 to 3850 psi, at temperatures to 650 F. Exceeding most recent military specifications, valves fea-

ture reliability, and resistance to vibration. There is almost no hysteresis, no pressure sag at increased pressures, and very small differential between cracking and reseat pressures. Size range is ¼-in. to ¾-in. tube size. **Vickers Inc.**, Box 302, Detroit, Mich.

Circle 457 on page 19

Single-Phase Motors

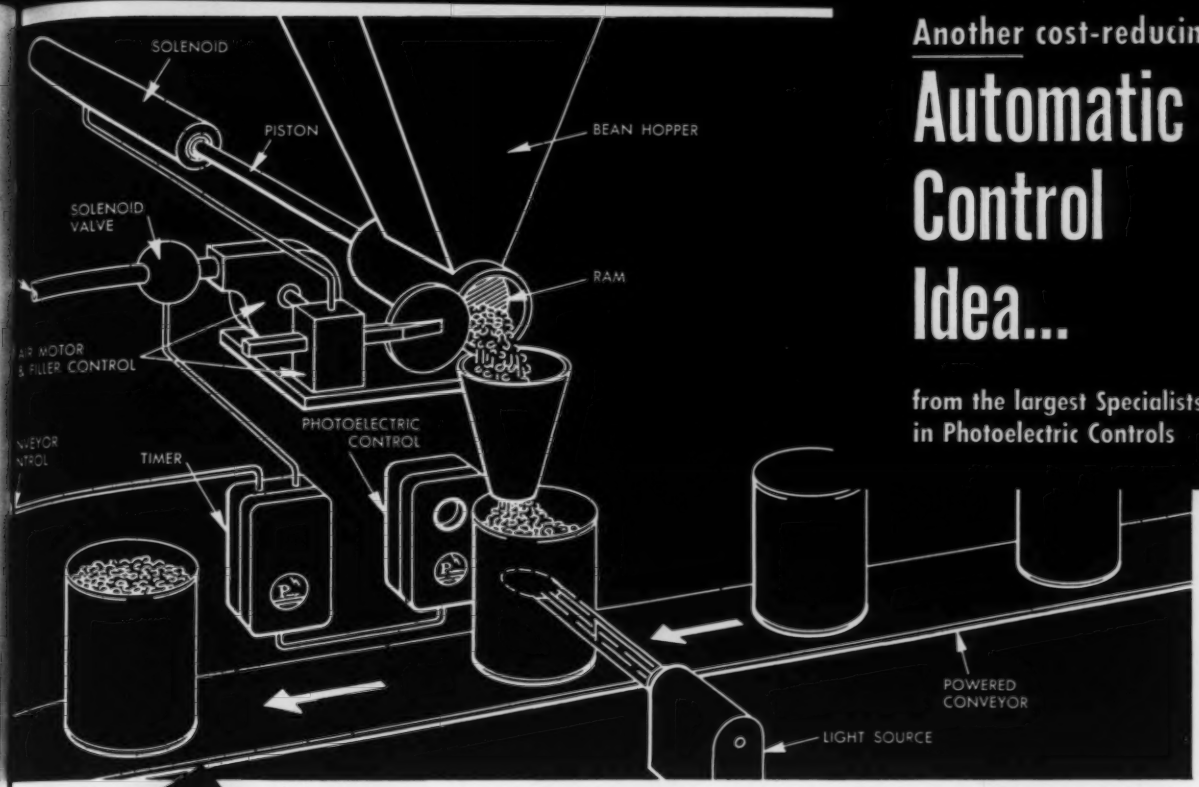
for farm equipment

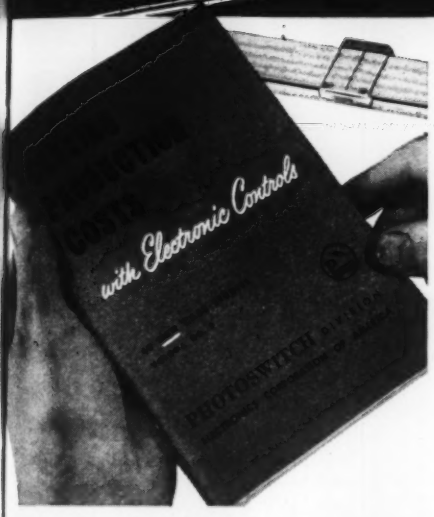
Two single-phase motors, designed for farm and farm equipment usage, are completely screened against rodents, treated for rust and corrosion resistance, and have lubrication and wiring instructions permanently attached. The repulsion-induction motor, unharmed by low voltages, has brush-holder parts of aluminum, copper, and

Another cost-reducing

Automatic Control Idea...

from the largest Specialists in Photoelectric Controls





Photoelectric Control of Batch Filling Process

Problem: To provide accurate, fast, fully-automatic control of filling aluminum bean-baking pots.

Solution: Empty pots move along a conveyor until one of them breaks the light beam of the photoelectric control at the filling station. The resulting electrical signal impulses a pre-set electronic timer. The timer instantly stops the conveyor, positioning the empty pot under the filling mechanism, and starts the automatic cycle of the filling mechanism. In the filling cycle, a filling-port cover is retracted, a measuring ram pushes a quantity of beans into the pot, and the filling port closes. At the end of the timed cycle, the timer automatically starts the conveyor again, the filled pot is moved away, and the light beam is restored until the next empty pot reaches the filling station.

Results: Reliable, high-speed filling of containers that are too light to provide sure operation of mechanical actuators. The timed cycle can be varied to allow for different filling times.

This control design is typical of thousands of successful Photoswitch Systems for automatic electronic control of machinery and processes. In Photoswitch's wide variety of high quality photoelectric controls, liquid level controls and electronic timers, you will probably find an exact answer to your automation requirements. Write for the helpful new Photoswitch Catalog . . . and if you have a specific problem, tell us about it.

FREE — 45 more ideas — Get this 76-page book. Shows in detail how designers of machines for many different industries have employed standard packaged electronic controls. Tells how they found new opportunities to reduce costs through simplification of design . . . how they developed order-getting user advantages. Shows you how easy it is to apply Photoswitch Controls for sorting, counting, starting, stopping, inspecting, indexing, adjusting, weighing, timing, limiting, safeguarding, etc.

SEND FOR YOUR COPY NOW ▶

Photoswitch DIVISION
ELECTRONICS CORPORATION OF AMERICA
Dept. P2-9, 77 Broadway • Cambridge 42, Mass.

Send FREE copy of "Cutting Production Costs with Electronic Controls."

Name and Title.....
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Address.....
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FIREYE DIVISION • COMBUSTION CONTROL DIVISION • BUSINESS MACHINES DIVISION
PHOTOCONDUCTOR-TRANSISTOR DIVISION • MARINE DIVISION • MILITARY DIVISION

Circle 573 on page 19

MESSAGE from the "NO" men of Laminated Shim Company

You lose **NO** time when you use LAMINUM SHIMS...

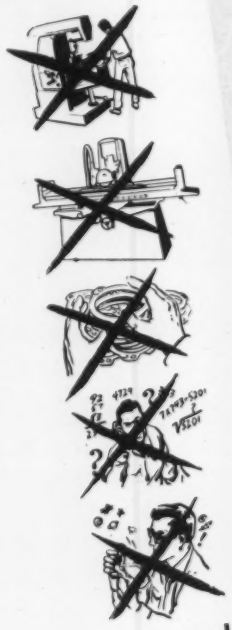
NO machining!

NO grinding!

NO counting!

NO stacking!

NO miking!



...and **NO** dirt between layers—ever!

LAMINUM®

SURFACE BONDED... THEY peel FOR ADJUSTMENT

Laminated Shims of **LAMINUM** now available in

STAINLESS STEEL with laminations of .002" or .003"	ALUMINUM with laminations of .003" only
BRASS with laminations of .002" or .003"	LOW CARBON STEEL with laminations of .002" or .003"

LAMINATED SHIM COMPANY, INC.

Shim Headquarters since 1913

1209 Union Street, Glenbrook, Conn.

Circle 574 on page 19

New Parts

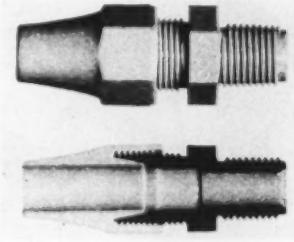
stainless steel or bronze, for corrosion resistance. Equipped with built-in manual reset, thermal overload protector, the repulsion-induction motor is manufactured in sizes from 1 to 7½ hp, and is suited for elevators, conveyors, unloaders, feed grinders, etc. The capacitor motor, in sizes 1 to 15 hp, is recommended for continuous duty on fans, driers, hay and grain blowers, pumps, etc. **Peerless Electric Co.**, Warren, O.

Circle 458 on page 19

Nylon Tube Fittings

join dissimilar metals without galvanic corrosion

Two-piece light-weight plastic fittings, for use with either metal or plastic tubing, are molded entirely from Zytel nylon. Eliminating galvanic action, fittings can be used to join brass, aluminum, copper and steel tubing. Complete line includes ⅛ to ½-in. tube and pipe sizes, and all units are interchangeable with comparable JIC fittings. Temperature range is from −70 to 295 F; seal withstands pressures to 500 psi. **Thomas Associates**, 4607 Alger St., Los Angeles 39, Calif.



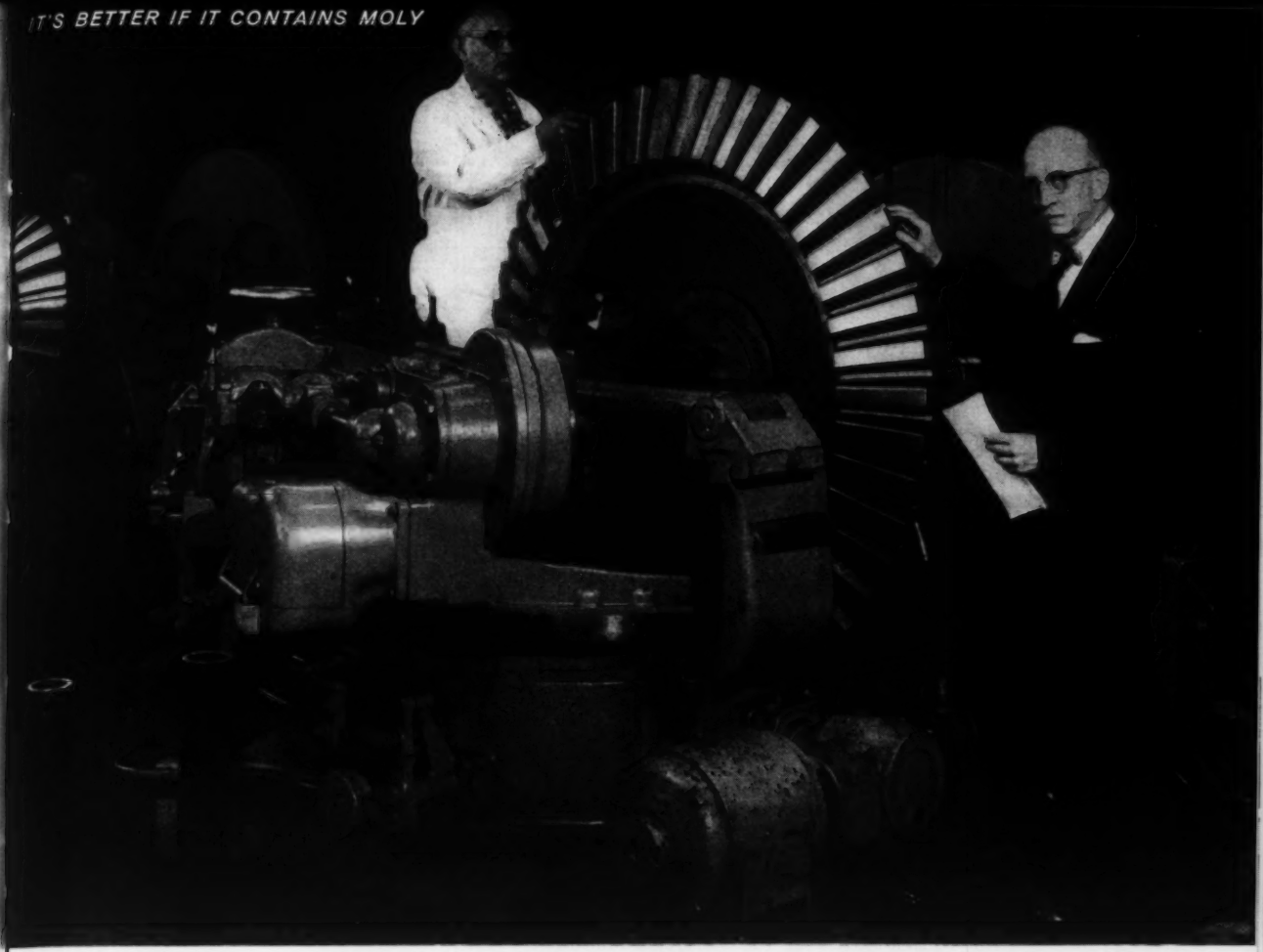
Circle 459 on page 19

Oil-Immersed Solenoid

withstands 34-million operating cycles

Oil immersed and individually sealed to avoid contamination of immersion oil by sludge and foreign materials, solenoid has die-cast case only slightly larger than solenoid of same rating in dust-tight cover. Unit has plug-in contacts and is secured in position by four captive bolts. Conforming to JIC specifications, unit is shock-mounted in two directions and op-

IT'S BETTER IF IT CONTAINS MOLY



E. B. Smiley, Metallurgist for Illinois Gear & Machine Co., looks over setup of large, heavy duty bevel gear made from molybdenum alloy steel casting. This gear has been rough turned, rough cut and heat treated to 269 to 302 Brinell before finish cutting.

For Strength, Hardness and Machinability gear maker recommends Molybdenum Alloy Steels

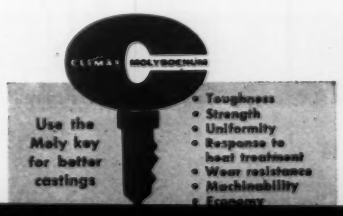
"All of our gears are made to customer specifications, and in many cases these include the use of molybdenum steels," says Mr. Smiley, metallurgist for Illinois Gear & Machine Co. "When our customers specify heat-treated gears of plain carbon steel," Mr. Smiley continues, "we often recommend that they change to 4140 alloy containing molybdenum to achieve high strength and hardenability with good machinability."

Moly steels offer gear users many advantages over carbon steel. Their greater strength and toughness permit the use of smaller weight-saving gears to transmit a given amount of power. Reduced weight and size of gear housings and other components add to the economy of moly steels. And their higher endurance is an important safety factor.

The properties of moly steels are discussed in a new booklet "Moly Steels for Cast Gears". Full technical assistance is also yours for the asking. Write Climax Molybdenum Co., Dept. 11, New York 36, N. Y.

CLIMAX MOLYBDENUM

Circle 575 on page 19



HANSEN SERIES RL
★ ★ ★
EFFECTIVELY HANDLES MORE VOLUME THAN ANY OTHER COUPLING OF EQUAL DIMENSION

HANDLES ANY APPLICATION ON AIR CIRCUITS REQUIRING ⅛" TO ¾" CONNECTIONS

Smaller!

Lighter!

Relative size of ordinary coupling required for effective handling of same volume

HANSEN

SERIES RL

QUICK-CONNECTIVE

RING-LOCK COUPLINGS

Hansen Series RL One-Way Shut-Off Couplings will handle any application on air line circuits requiring ⅛" to ¾" connections. All Hansen Series 2-RL Sockets and Plugs are interchangeable with each other. Likewise, all Sockets and Plugs of the slightly larger, greater capacity Series 3-RL are similarly interchangeable with each other.

Consequently, by standardizing on either Hansen Series 2-RL or Series 3-RL Couplings, you make it easy for users of your product to keep stock of parts in balance – hold inventories to a minimum.

Locking ring provides positive lock and assures tight fit. Equipped with automatic sleeve lock.

Two-Way Shut-Off and Straight-Through Couplings also available.

WRITE FOR CATALOG

SINCE 1915 ® QUICK-CONNECTIVE FLUID LINE COUPLINGS

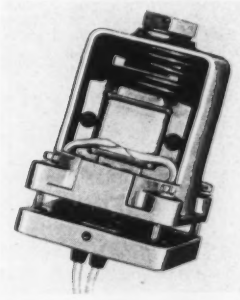
THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 11, OHIO

Circle 576 on page 19

New Parts

crates 35 to 50 F cooler than standard models. Test solenoids show no measurable wear after 8½ million strokes at 24 strokes



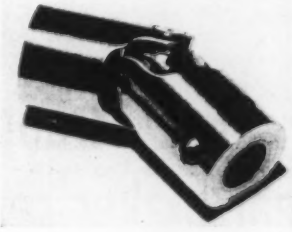
per minute and only superficial wear after 34 million strokes at 300 strokes per minute. **Detroit Coil Co.**, 2435 Hilton Rd., Ferndale, Mich.

Circle 460 on page 19

Universal Joints

in sizes up to ¼-in.

Precision universal joints are of stainless steel, passivated to meet military requirements. Operable



at angles up to 30 deg, the joints are available with bores of ⅛, 3/16, and ¼-in. **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook, L. I., N. Y.

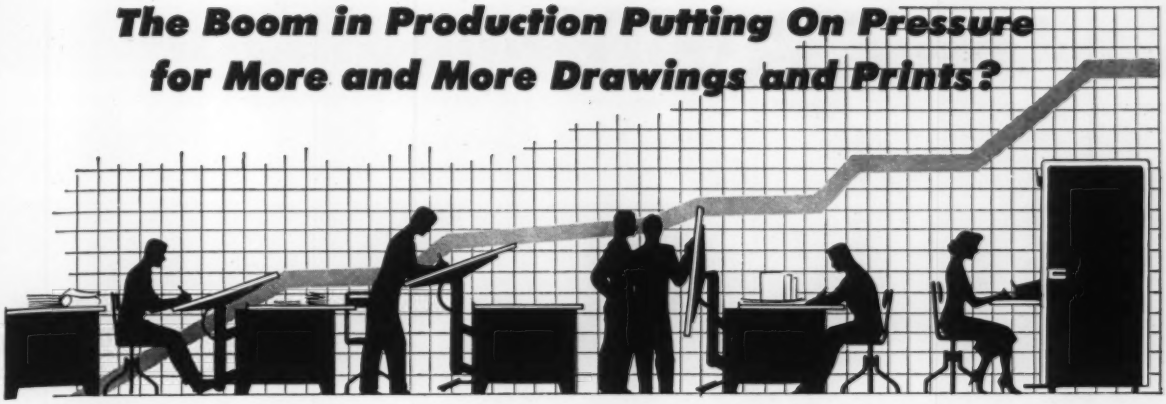
Circle 461 on page 19

Limit Switch

has watertight plastic cover

Cover on this limit switch is an acrylic plastic material held in position by a steel frame and captive cover screws. Watertight neoprene gasket provides a positive water seal between the housing of the switch and the cover. The operator can observe the contact action in the interior of the switch without removing the cover. Seven

The Boom in Production Putting On Pressure for More and More Drawings and Prints?



NOW Is the Time to Get Your New Modern BRUNING Copyflex Machine!

Two Great New Models for the Large Or Small Engineering Department!

If your company, like most others, is gearing up for greater-than-ever production, it will mean more pressure on your drafting room for engineering drawings and prints. You couldn't pick a better time to get a new modern reproduction machine. And you couldn't make a wiser choice than efficient, trouble-free Copyflex.

In just the last year, Bruning has introduced five new advanced machine models, two of which are shown here. These machines cover the reproduction needs of engineering departments, from the smallest to the largest. They offer you the famous problem-free installation and operation of Copyflex . . . no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection. They bring you faster reproduction and a host of operator conveniences that will help you boost drafting room output, keep costs at a minimum.

Now is the time to act. Mail the coupon below. You will be glad you did.

New Copyflex Model 500. A new, fast, heavy-volume machine offering top mechanical speed of 40 f.p.m., 46-inch printing width, automatic separation, front or rear delivery, automatic stacking, and a host of other advanced features.

New Copyflex Model 300. An all-new, low-cost tabletop model offering 30-inch printing width, up to 9 f.p.m. mechanical speed, 110 volt operation. Brings the advantages of "inside" reproduction within the reach of the smallest engineering department. Enables the largest company to supplement, economically, its reproduction center with additional, strategically located model 300's.

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☐ Model 500 ☐ Model 300.

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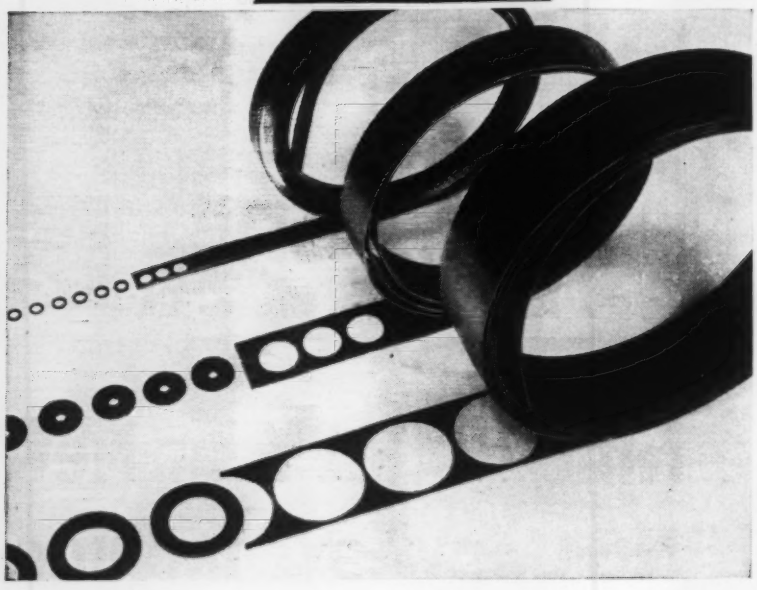
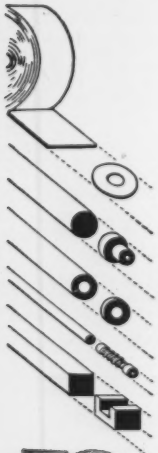
POLYPENCO® NYLON SHAPES



NYLATRON® GS Nylon Thrust Washers

Resist Wear • Reduce Noise
Provide Smooth Operation Without Lubrication

NYLATRON GS Nylon thrust washers—rapidly stamped from coiled strip—outlast other materials wherever there are thrust loads between metal parts—such as in fractional horsepower motors.



NYLATRON GS:
A molybdenum disulphide filled nylon* formulated to expand the field for nylon. It has a higher heat distortion temperature and lower thermal expansion than standard Nylon 101, combined with a lower coefficient of friction and higher wear resistance in many applications.

HIGHEST QUALITY:
You can expect highest quality nylon with POLYPENCO stock shapes . . . freedom from porosity, uniform properties and maximum dimensional stability.

STOCK SHAPES READILY AVAILABLE:
POLYPENCO Nylon stock shapes are available in rod, strip, tubular bar, tubing and slab. POLYPENCO standard and special nylon formulations are easily machinable on metalworking equipment.

FABRICATED PARTS:
Fabrication service is available for your parts—engineered for the best in design, quality and tolerance. Write to the Technical Service Department for help on your application.

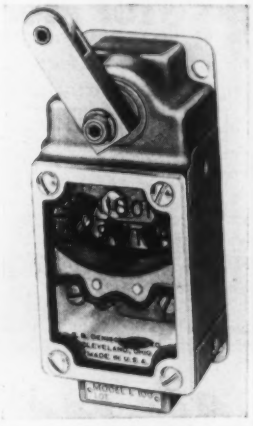
THE POLYMER CORPORATION OF PENNA. • Reading, Penna.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO Nylon, Teflon†, Q-200.5 (cross-linked polystyrene) and K-51 (chlorinated polymer)

*PATENTS APPLIED FOR
†DU PONT TRADEMARK

Circle 578 on page 19

New Parts



Loxswitch models and 19 contact arrangements are available with the watertight covers. **R. B. Denison Mfg. Co.**, 102 St. Clair Ave., N. W., Cleveland 13, O.

Circle 462 on page 19

Glass-Mat Laminates

have high impact strength, dimensional stability

Polyester resin glass mat laminates, for use as armature slot wedges, spacers, switchboard panels, arc chutes, etc., have exceptionally high impact strength, combined with above-average arc resistance. Physical properties also suggest use in mechanical applications, such as in fabricated containers, cams, etc. Available in three grades with varying electrical and mechanical properties, the resins have good chemical resistance to both acids and solvents. They have fair resistance to weak alkalies, but are attacked by strong alkalies. Standard sheet sizes are 32 by 36 in., 32 by 48 in., and 32 by 74 in. **National Vulcanized Fibre Co.**, 1056 Beech St., Wilmington 99, Del.

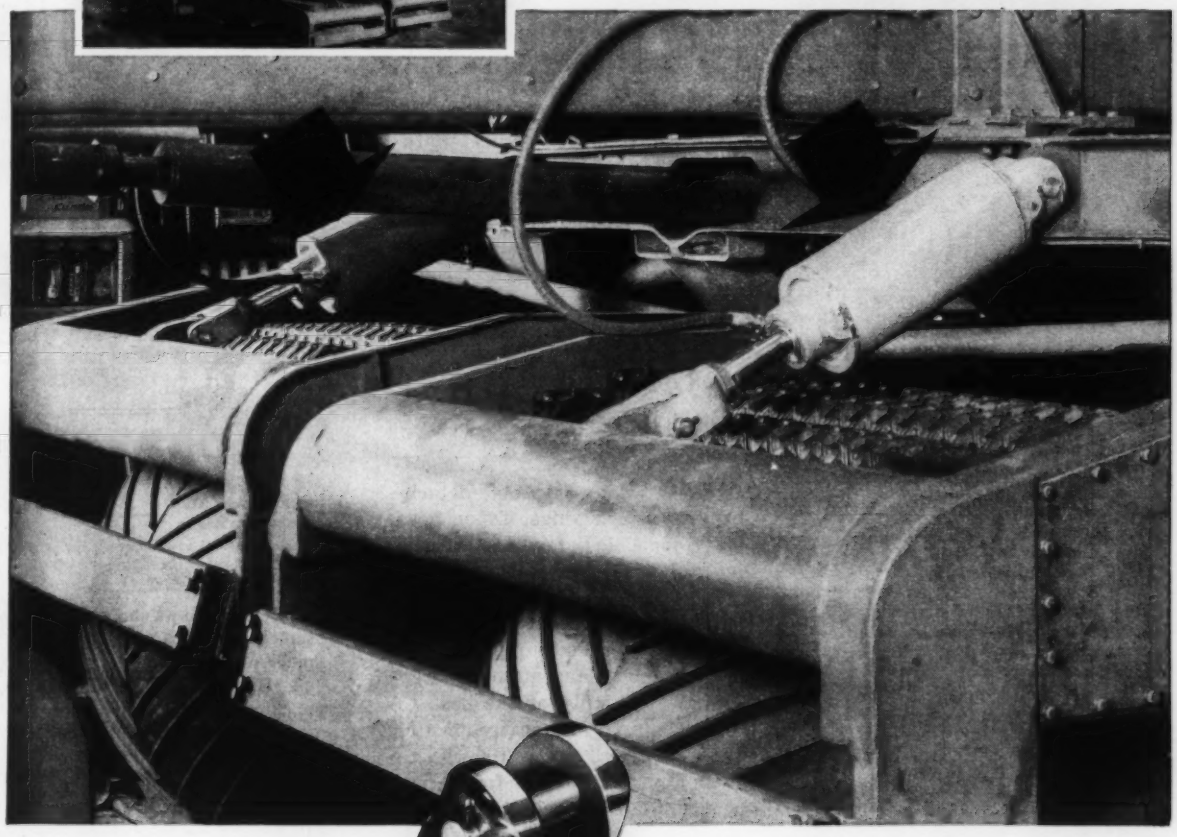
Circle 463 on page 19

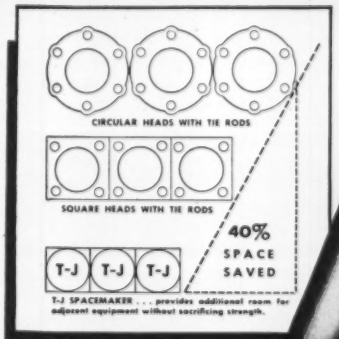
Electronic Potentiometer

transmits pneumatic signal

Equipped with a pneumatic transmitter, this electronic potentiometer sends a 3-15 psi signal proportional to the measured variable. Available with either potentiometer or bridge circuits, the instrument measures any variable which can be translated into an

Arctic Cargo Carrier Depends On T-J Spacemaker CYLINDERS




CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

Saves 40% Space!
No Tie Rods For Greater Strength

Differential axle loading through T-J Spacemaker Air Cylinders forms a controlled walking beam in this Teracruiser, designed and produced for the Army Ordnance Corps by the Four Wheel Drive Co., Clintonville, Wis.

Weight of cylinders was important factor in choosing T-J Spacemakers, which reduce weight while providing same displacement and extra high safety factor. Fast delivery and space-saving features also favored T-J. Exclusive with T-J are new Super Cushion Flexible Seals for Air (to 200 P.S.I.) . . . and New Self-Aligning Master Cushion for Oil (to 750 P.S.I.). Hard chrome plated bodies and piston rods are standard, at no extra cost. Wide range of styles, capacities . . . 64,000 combinations *off the shelf!* Write for bulletin SM-155-3. The Tomkins-Johnson Co., Jackson, Mich.

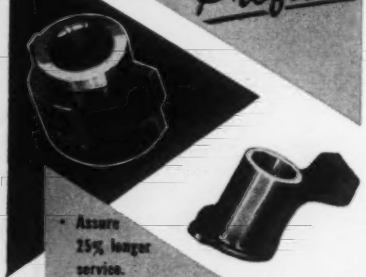
ALL MODELS . . . OFF SHELF DELIVERY

MEETS WITH ALL JIC RECOMMENDATIONS

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

Promet
Engineered Bronze

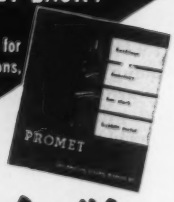
BEARINGS
BUSHINGS
WEARING PARTS
Save Money—
Increase
Profits!



- Assure 25% longer service.
- Will not cut or stick to the shaft under ordinary operating conditions.
- Carry on during temporary lubrication failures.
- Will not powder under the most severe service.

Special formulas, developed for specific or unusual conditions, assure the best combination of physical properties.

Superior Service Guaranteed
OR YOUR MONEY BACK!
SEND PRINTS
and condition of operation for recommendations, quotations, literature and service data sheets.

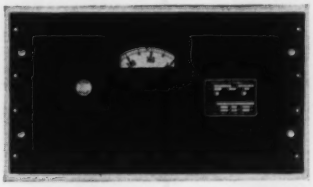


The
American Crucible
PRODUCTS CO.
"Bearing Specialists Since 1919"
1321 OBERLIN AVENUE, LORAIN, OHIO, U.S.A.
Please send free literature and service data sheets on Promet Bronze.
NAME_____
COMPANY_____
STREET_____
CITY & STATE_____

Circle 580 on page 19

New Parts

electrical quantity, such as speed, viscosity, *pH*, current, pressure, temperature, and smoke density. Measurement is converted into a



pneumatic signal for transmission to remote pneumatic indicator, recorder, or automatic controller. Unit has standard electronic and pneumatic components and is available with or without indicating scale. **Bristol Co.**, Waterbury 20, Conn.

Circle 464 on page 19

Teflon Hose

with leak-proof detachable fittings

Available with leak-proof, detachable reuseable fittings, Teflon hose is recommended for applications involving wide temperature ranges and injurious chemical action. Hose is nearly inert to most chemical action as found in applications in the chemical and atomic energy industries. Ability of the hose to handle material and environmental temperatures from −100 F to +500 F is also useful for carrying steam, hot asphalt, and similar materials. Detachable, reusable fittings, available with male pipe and JIC swivel fittings, are leak-proof even after aging of hose, are assembled with simple hand tools, and may be reused many times. **Aeroquip Corp.**, Industrial Sales Dept., Jackson, Mich.

Circle 465 on page 19

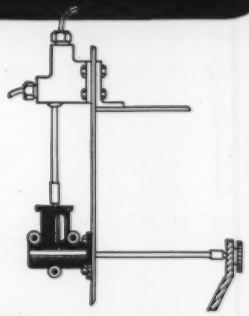
Braking System

is manually set, hydraulically released

Hydraulic brake system has spring-set, hydraulically released parking brake, manually controlled without electric power. Known as HM-3, the system provides service and parking brakes where uninterrupted power supply is not available, eliminating automatic park-

ANGLgear

simplifies the problem of 90° drive



There's an ANGLgear to solve virtually any 90° power take-off problem on either manual or power-operated equipment.

Replace bulky chains and sprockets with ANGLgear, the modern right-angle power take-off. High capacity ANGLgear requires little space and can be mounted four different ways. Thus ANGLgear is easily incorporated in your power transmission system.

You can depend on ANGLgear for long, maintenance-free service. Rugged ANGLgears have hardened bevel gears, ball bearings, and are permanently sealed and lubricated.

Why pay for expensive custom-made drives? Standardized ANGLgear is available immediately from stock in 3 sizes and 12 models, offering you 1-1 or 2-1 gear ratios and 2- or 3-way shaft extensions. See our literature in Sweet's product design file; then contact your local distributor or write us for information.

AIRBORNE®
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 581 on page 19

GREGORIO JARQUE and SON demonstrate the little sheave with the big grip

Easy on Bruce Jarque uses a standard wrench to assemble.

Easy off Two pull-up screws are used to break the cone grip.

Yet always tight on the shaft
Gregorio Jarque is no match for the QD Junior.

Exclusive tapered, split hub on Worthington QD Junior sheave grips the shaft so tightly it can't be dislodged

This two-piece, light-weight sheave has a heavyweight's grip. An exclusive tapered, split hub grips the shaft so tightly wrestler Gregorio Jarque can't dislodge it. Tests show the Worthington QD Junior will remain tight even under a torque force of 3300 pounds.

It's built for staying power—won't loosen or slip under shock or pulsating loads. Yet it's always easy to remove from the shaft.

Some other money-saving features of the QD Junior:

One Common Hub is standard for 54 stock sheave sizes, ranging from 3.2 to 18.4 inches pitch diameter.

Tapped Holes allow use of pull-up bolts as jack screws to break cone grip when removing rim from hub.

Heavy Hex Head Bolts fasten rim to hub. No special tools are required to remove or install the QD Junior. A standard hex socket wrench is all that's needed.

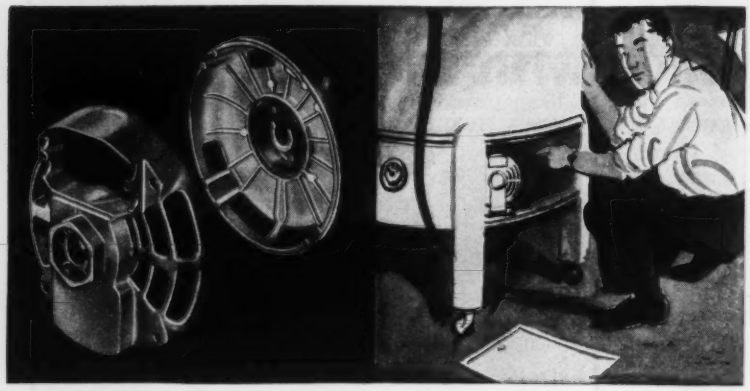
I-beam Arm (in larger sizes) gives more strength with less weight.

You'll find it's easy to select the proper light-weight sheave and FHP V-belt drive from bulletin FHP-100-B1A. Write for your copy today. Worthington Corporation, Section MV65, Oil City, Pa.

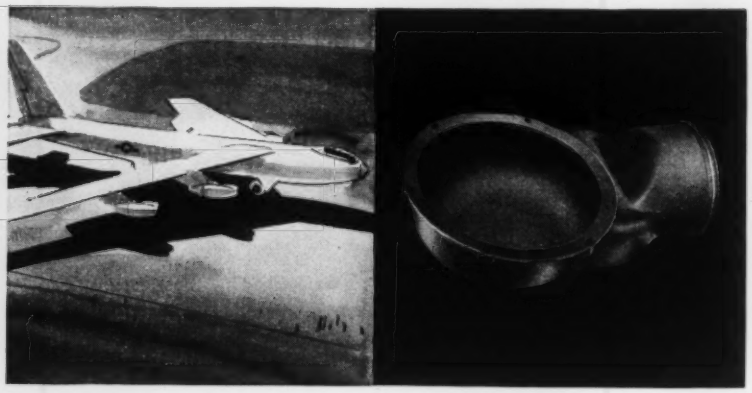
MV.6.5

WORTHINGTON

Circle 582 on page 19



Washing Machines and Jet Planes



Thompson Light Metal Castings and Impact Extrusions Serve All Industry

MILADY'S washing machine and the jet plane overhead have one thing in common—both *can count on Thompson.* For, in each, you'll find precision-engineered castings produced by Thompson's versatile Light Metals Division.

Among several parts produced by Thompson for use in washing machines and other appliances are end frames for electric motors. And Thompson's exacting light metals engineers have produced numerous parts for the speedy jets —including a die cast air connector, used for cooling electric generators.

These are but two of the many light, strong, durable castings designed, developed, and manufactured by Thompson. Behind today's versatile light metals operations are over 50 years experience in research and manufacture of precision parts, enabling Thompson to offer its facilities to all forms of industry.

Thompson is now producing light metal castings for such diversified products as buses and garbage disposers; tractors and outboard motors; automobiles and industrial engines; ice scoops and aircraft engines.

Regardless of your product, if you use castings or impact extrusions, Thompson's creative engineers will gladly show you where and how you can simplify your operations and save on costs with Thompson Light Metals Castings.

We want to quote on your plans and specifications. Write, wire or phone Dept. MD-9, Light Metals Division, Thompson Products, Inc., 2269 Ashland Road, Cleveland 3, Ohio, HEnderson 1-6765.

You can count on

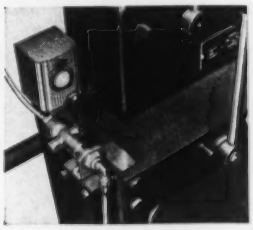
Thompson Products

LIGHT METALS DIVISION

2269 Ashland Rd. • Cleveland 3, Ohio

Circle 583 on page 19

New Parts



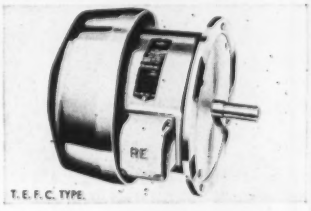
ing upon power failure. Parking brake is released by control cylinder foot pedal, and remains released until manually set by tripping hydraulic check valve. Signal light remains on while brake is set. **Wagner Electric Corp.,** 6400 Plymouth Ave., St. Louis 14, Mo.

Circle 466 on page 19

Precision Motors

for machine tools

Built for powering machine tools, motors have dynamically balanced rotors and extra heavy bearings for vibrationless operation. Motors are radial air gaps and have



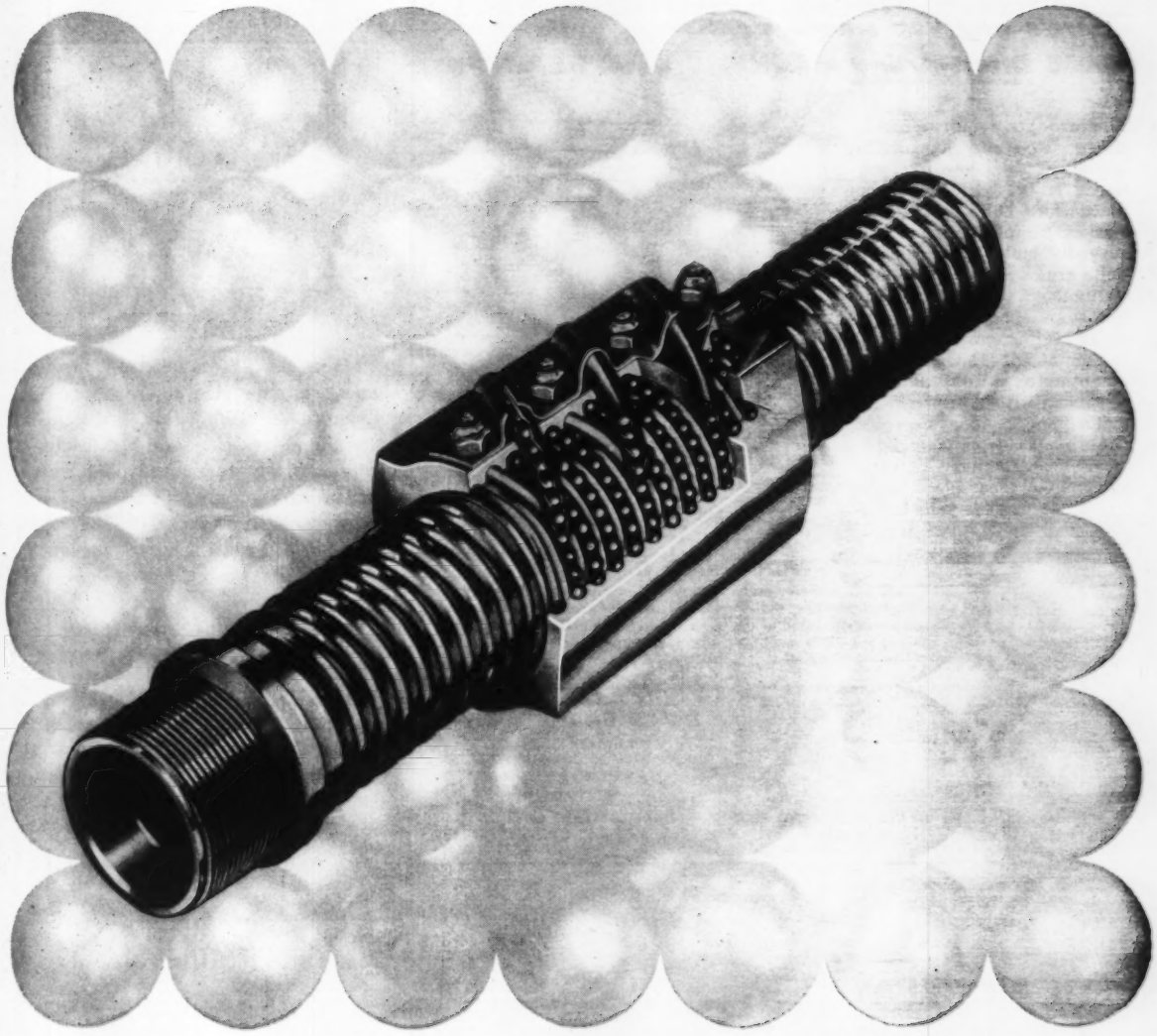
thin, light weight, low-inertia rotors for smooth starting and rapid stopping. Available in TEFC and TENV types, rating is from ½-hp to 3 hp, continuous or intermittent duty. **Reuland Electric Co.,** 3001 W. Mission Rd., Alhambra, Calif.

Circle 467 on page 19

Mixing Valve

blends cold water and steam to make hot water

Cold water and steam are automatically mixed to provide hot water at any desired temperature by style D mixing control. Single-handle control regulates temperature of the discharged hot water at any point from that of the incoming water to 200 F, regardless of pressure changes in supply lines. Check valves built into each inlet prevent interchange of steam and cold water when the mixer is



how Vacuum Metals' FERROVAC boosts ball bearing screw life up to 400%...

Ball bearing screw assemblies, first used in automobile steering mechanisms, are now found in such critical applications as the actuation of landing gear and control surfaces of aircraft and guided missiles. And it was in tough jobs like these that the assemblies failed in fatigue. Then a leading manufacturer tried vacuum-melted FERROVAC® for the balls – and service life rose as much as 400% over the original life. Here's why...

Vacuum melting improves fatigue properties – It literally sucks gaseous impurities – focal points for fatigue failure – from the molten metal. Vacuum-melted metals are cleaner, purer, tougher. And cleanliness means an added bonus in fewer rejects.

Only Vacuum Metals gives you one-source service – Vacuum Metal's own large organization, and its affiliation with National Research Corporation and Crucible Steel Company of America, means a fully integrated service from melting and casting through mill rolling and nationwide distribution of finished mill products. And you can get not only small experimental lots, but now, thanks to our new 2500 lb. induction furnace – the nation's largest – you can also get large-scale continuous production quantities of vacuum-melted metals. If you have an application which these unique metals may improve, please write giving full details. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*

VMC

VACUUM METALS CORPORATION

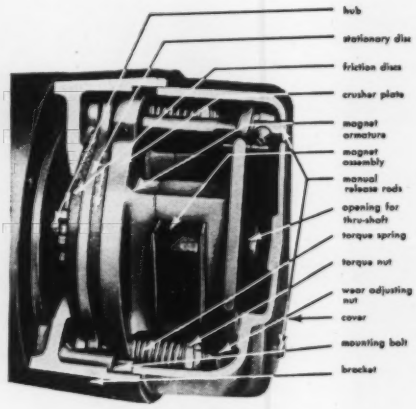
Jointly owned by Crucible Steel Company of America and National Research Corporation

Circle 584 on page 19

Here's why you should specify

DINGS *Direct-Acting* MAGNETIC DISC BRAKES!

Wherever you require a quick, smooth stop and dependable holding, with low maintenance costs . . . that's the place for Dings Magnetic Brakes. Simply designed and ruggedly built, these efficient units are *direct-acting* for instantaneous release and positive stops. There are no mechanical linkages and levers to maintain. Designed for mounting on all old and new re-rated NEMA type "C" motor flanges. *Always specify Dings Brakes* from your regular motor supplier . . . ask about Dings complete engineering service for your brake problems.



THRU-SHAFT DESIGN

While a Dings Brake accommodates the standard NEMA shaft extension, eliminating the necessity of using special shaft extensions, a simple modification of the cover converts the brake for Thru-Shaft applications. This facilitates direct coupling, use of hand cranks, tachometer, plugging switch, pulleys, etc.

Write for Bulletin BK4003

DINGS BRAKES, INC.

A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.

4714 West Electric Avenue

Milwaukee 46, Wisconsin

See our Catalog in SWEETS PRODUCT DESIGN FILE. Section 5a/Di

DB156

Circle 585 on page 19

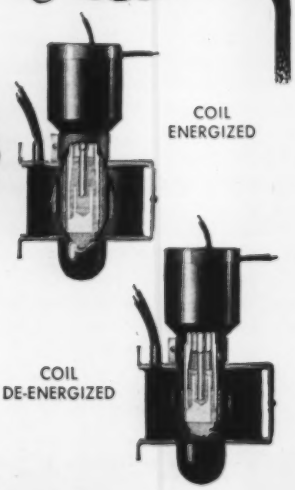
The

TIMER RELAY that eliminates controlled timing problems

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

Durakool

STEEL MERCURY TIMERS



This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Any combination of operate-release time delays from 0.15 sec. to 20 sec. — either normally open or normally closed action.

See telephone directory for local distributor, or write.

DURAKOOL, INC.

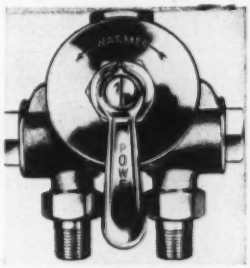
ELKHART, INDIANA, U.S.A.

700 WESTON RD., TORONTO 9, CANADA

Send for Bulletin 800

Circle 586 on page 19

New Parts



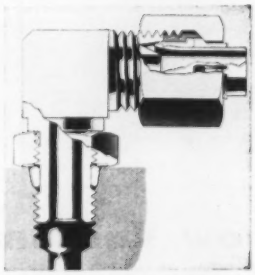
not in use. Temperature adjustment handle also operates an internal shut-off valve. Mixer is available in ½ and ¾-in. sizes. Pressure of steam and cold water may vary from 10 to 100 psi. **Powers Regulator Co.**, 3434 Oakton St., Skokie, Ill.

Circle 468 on page 19

O-Ring Fitting

is leakproof under high pressures

Straight-thread, O-ring locknut fitting is leakproof under high-pressure connections and is easy to position. Interchangeable fit-



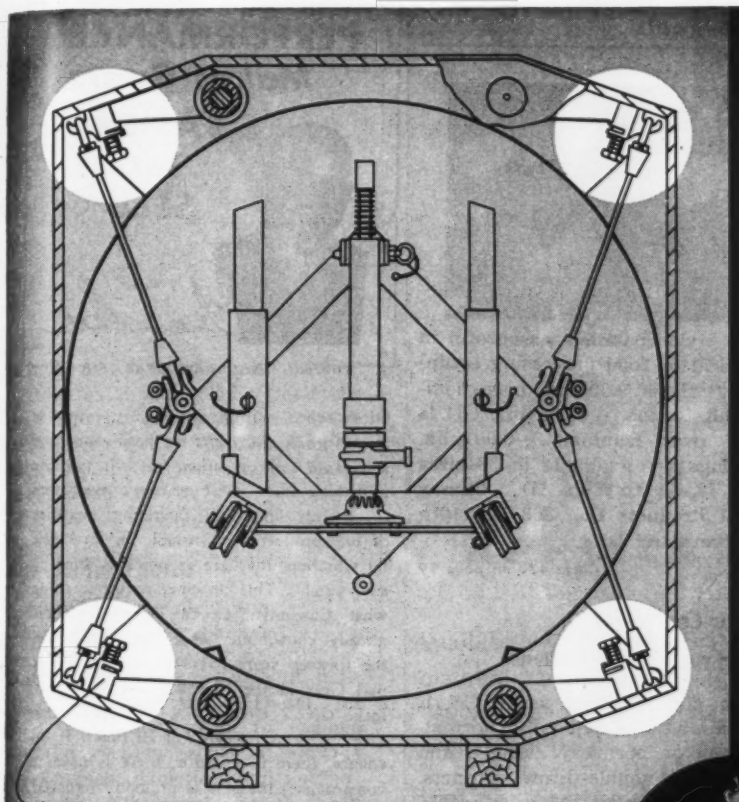
ting meets JIC and SAE standards, and is available in all standard styles, sizes ⅛-in. through 2 in. **Flodar Corp.**, 16911 St. Clair Ave., Cleveland 10, O.

Circle 469 on page 19

Nylon Bearings

straight and flanged in 39 stock sizes

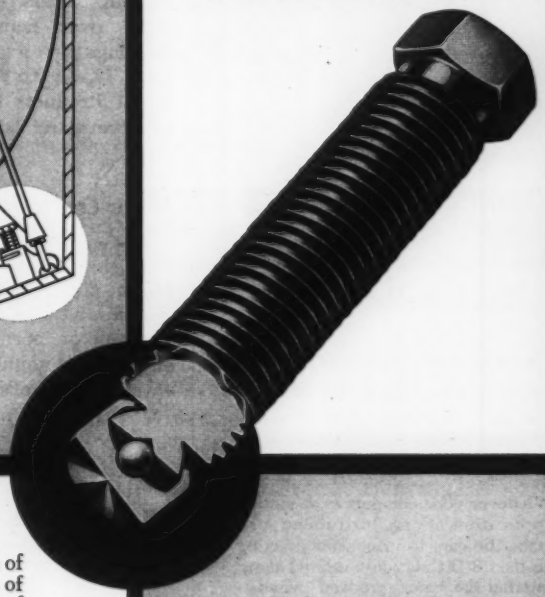
Requiring no lubrication, nylon bearings are suited for applications involving heavy loads at low rotative speeds, or light loads at either high or low speeds. Bearings have been used on loads in excess of 206 psi at rubbing speeds of 525 fpm. Insoluble in common organic solvents, alkalis, dilute mineral acids, and most organic



Vlier makes only the Swivel-Pad Clamps. The container is a product of American Pipe and Steel Corporation, Alhambra, California.

Vlier Ball-joint clamps

solve clamping problem for missile container manufacturer



The remarkable ball-joint design now used in thousands of Vlier Swivel-Pad Clamps can be adapted to a variety of clamping and holding applications. The drawing above of a missile shipping container demonstrates one adaptation which solves a particularly difficult problem. Eight special Vlier Swivel-Pad Clamps are used to release tension on cables which suspend the missile in its shipping container. Radar manufacturers are also using special Swivel-Pad Clamps to prevent damage to sensitive instruments during shipment.

PROTECTS SURFACE OF THE PART

The main advantage of the Vlier Swivel-Pad Clamp is that it exerts extreme holding pressure without damaging the surface of the object held. First touch of the pad against the object adjusts the pad face angle and stops pad rotation. The pad can then be tightened to hold the object securely, since the screw torque is absorbed by the pad, not the object.

Perhaps this unique Vlier ball-joint principle can be applied to your clamping problems. Vlier engineers will welcome your inquiries.

BALL-JOINT CONSTRUCTION—Eliminates binding, assuring proper adjustment of the pad against an off-angle surface. The pad swivels 7½° in all directions each side of the center line.

SPECIAL PAD AND SCREW DIAMETERS AVAILABLE—Normally pads are machined from solid stock and are not relieved or counterbored. However, other shapes, sizes, etc., can be designed to meet specific needs.

EXCELLENT STRENGTH—Screws are made from heat-treated alloy steel. Ball-joints have been designed to withstand as much as 21,000 load pounds (1" screw diameter).

VARIETY OF FINISHES POSSIBLE—Standard Swivel-Pad Clamps are Du-lited: however, cadmium, iridite, and other finishes to meet government specifications can be provided.

Insist on Vlier Tooling Accessories...
there's still no substitute for quality.

VLIER ENGINEERING INCORPORATED

8900 Santa Monica Boulevard
Los Angeles 46, California

PRECISION CAMS

from FORD INSTRUMENT

FLAT CAMS | 3D CAMS | BARREL CAMS

- offered in a variety of types
- with tolerances to ±0.0005"
- for wide range of computing and motion applications

Whatever your computing or motion application, Ford Instrument can make the cam to meet your exacting needs...3-D Cams, grooved flat cams, external flat cams, grooved cylindrical cams. The Company's unique cam-production facility – and many years of experience – guarantee unmatched performance in this field.

FREE – Fully illustrated data bulletin gives specifications and performance information. Please address Dept. MD.

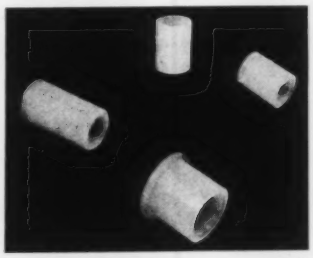
58

FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
31-10 Thomson Ave.
Long Island City 1, N. Y.

Ford Instrument's standard components

Circle 588 on page 19

New Parts



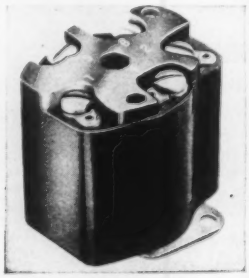
acids, nylon bearings are useful in chemical or food processing equipment. ID is 0.005 in. over nominal shaft size, ±0.001 in.; OD is 0.004 over nominal, ±0.001 in. Bearings are available in 39 sizes from ¼-in. to 1-in. ID. **Climax Metal Products Co.**, 863 E. 140th St., Cleveland 10, O.

Circle 470 on page 19

Motor Controller

for rugged applications

Motor starter relay, series C-141, is available in single-pole (normally open or normally closed), and single-pole double-throw contacts. Rating is 1 hp at 115 v ac or 1½



hp at 230 v ac, 60 cycles. Unit is designed for extra-rugged commercial applications. Size is 1 31/32 x 2 3/32 x 1 53/64 in. **U. S. Relay Co.**, 1740-44 Albion St., Los Angeles, Calif.

Circle 471 on page 19

Timer Switch

controls single, multiple or sequential circuits

Supplied in timing ranges from 60 sec to 12 hr, Mark-Time switch can be used on many types of industrial and commercial equipment, as well as on consumer appliances, such as clothes dryers, dish washers and ranges. If multiple circuits must be controlled, as many as four extra housings

PERFORMANCE Makes Gears EASIER TO SELL

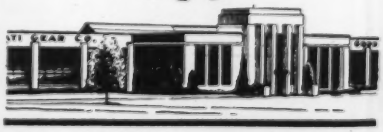
REPRESENTATIVE, THE CINCINNATI GEAR CO.

Often when calling on a new customer after his first gear order has been assembled and is in test operation, he will tell me something like "finest gears we ever used — certainly improved operating qualities of our product — no trouble in assembly, no vibration, they are as quiet as a precision watch". This customer is just learning what Cincinnati Gear's older customers already know, and what I've known for the thirteen years I've represented Cincinnati Gear in the Cleveland area: that we make *ONLY GOOD GEARS* — gears that give 100% performance at all times. If, by chance, there is an error, there is never a compromise; the gear is promptly replaced.

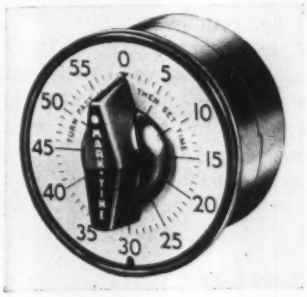
This pleases our customers, of course, but it also pleases me — and gives me the confidence in our firm and our product that I need to do a first-rate selling job. This confidence, I feel, is about the most valuable "sales aid" I have. I can solicit an order and know full well that the gears shipped will deliver performance desired — and result in the kind of customer satisfaction that leads to repeat orders. I can't think of anything that makes my job easier.

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
"Gears—Good Gears Only"

CINTI



Circle 589 on page 19



can be added to one unit. Switch rating is 28 amp, 250 v, and the unit can be used effectively as a high-low switch. **M. H. Rhodes Inc.**, 30 Bartholomew Ave., Hartford, Conn.

Circle 472 on page 19

Dynel Mat Fabric

with high chemical and low electrical resistance

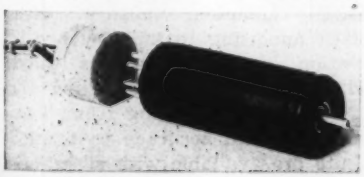
Nonwoven textile consists of multiple webs containing Dynel, an form a resilient sheet in various form a resilient sheet in vairous thicknesses, densities, and surface textures. Thermoplastic, the mat can be permanently folded, molded into special shapes, and surfaced with strengthening ribs or embossing. Tensile strength may vary from low to high, density from 5 to 25 lb per cubic ft. Surfacing may be soft or hard, coarse or fine. Mat has high chemical resistance and low electrical resistance. Uses are for separators in lead-acid and nickel-cadmium alkaline batteries, filtering air and corrosive liquids, sound absorbing material, fabric stiffeners, and diaphragms. **Felters Co.**, 210 South St., Boston 11, Mass.

Circle 473 on page 19

Induction Potentiometer

has input windings on stator

Size 11 induction potentiometer has windings on stator to relieve brushes and collector rings from carrying current. Linearity of

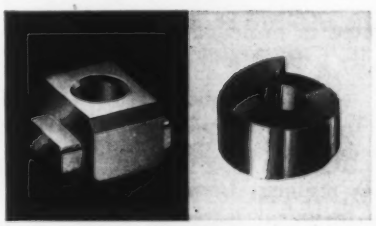


A NEW FREEDOM IN BEARING APPLICATIONS

Availability of Sintered Powdered Metal Bearings and machine parts from a fully competent and technically responsible source opens the way to improvements in mechanical products.

Bunting facilities for designing, engineering and manufacturing of Sintered Powdered Metal Bearings and parts are as comprehensive and responsible as the traditional Bunting competence in the field of Cast Bronze Bearings.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.



Write to our Product Engineering Department in Toledo or consult our nearest Sales Engineer.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 590 on page 19

A call to any one of our seven warehouses will get you speedy service on your order . . . whether it's for *alloy steel bars, billets or forgings,* in any size, shape or treatment you need.

All seven warehouses are located in principal industrial areas. Each is modern and well-stocked, and staffed by expert metallurgists.

Call now if you need our own HY-TEN steels – "the standard steels of tomorrow", or standard AISI or SAE grades.

Or write for *free* copies of Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

In Canada: Sanderson-Newbould, Ltd., Montreal and Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.

133 Sidney Street, Cambridge 39, Massachusetts

Circle 591 on page 19

New Parts

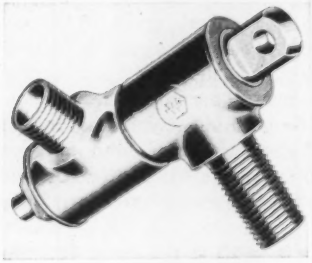
±0.1 per cent over range of 0 to 75 F, input impedance up to 750 ohms, phase shift of ±5 min with rotor position, and maximum null voltage of 1 mv per volt of input, are given by 4.7-oz unit which operates at 70,000-ft altitude without pressurization. **Diehl Mfg. Co.,** Finderne Plant, Somerville, N. J.

Circle 474 on page 19

Swivel Joint

low-torque units snap together to make assemblies

Pressure - balanced, low - torque swivel joint is of plane-type design, and does not depend upon piping to rotate. Shaft may be actuated by mechanical drive rod thus eliminating tube fatigue at piping connections. Suitable for hydraulic, pneumatic, gaseous, and



vacuum carrying installations in aircraft systems, stock assemblies are selected and snapped together to make up different arrangements to suit applications. Swivels are corrosion-proof and operable through a wide temperature range. **Weatherhead Co.,** Aviation Div., 300 E. 131st St., Cleveland, O.

Circle 475 on page 19

Drum Dial and Vernier

can be read to 6 min accuracy

Engraved drum dial and vernier sets are available from stock in four sizes: 1½, 2, 2½, and 3-in. diam. Vernier sets are made of 24ST aluminum, finished with black anodizing to military specification, and engraving is filled with white. Engraving consists of 1-deg steps, reading from 0 to 360 deg, with accuracy to 6 min. Units are available with stainless-

PHOENIX Custom Rubber Molding

we will work with you!

Our knowledge and experience gained from twenty years' development work is at your disposal. Should you desire assistance in mold, die, or product design, you have only to call on us.

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RUBBER PRODUCTS DIVISION
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Joliet, Illinois

GET THE FACTS ON

GRAPHALLOY

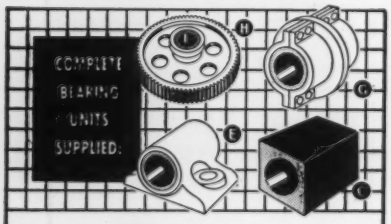
LONG WEARING
LOW FRICTION

UNIQUE (OIL-FREE)

SELF-LUBRICATING
BUSHINGS

EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE (−450° to +700°F.) OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR LIQUID GASES • NON-CONTAMINATING IN FOODSTUFFS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



BRUSHES • CONTACTS

GRAPHALLOY has high-performance electrical properties: low electrical noise, low and constant contact drop, high current density, minimum wear!

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

USE OUR 40 YEARS OF DESIGN EXPERIENCE!

GRAPHITE METALLIZING CORPORATION

1045 Nepperhan Ave. • YONKERS, NEW YORK

☐ Please send data on Graphalloy Oil-Free BUSHINGS.

☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE

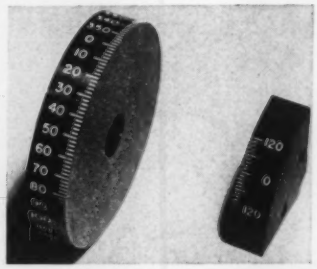
COMPANY

STREET

CITY ZONE STATE

Circle 593 on page 19

New Parts



steel hubs and in a wide range of bore sizes. **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook L. I., N. Y.

Circle 476 on page 19

Vertical Motors

in new NEMA standards, 1 to 30 hp sizes

Enclosed Type HV solid shaft motor conforms to new NEMA dimensional standards, and is available from 1 to 30 hp with NEMA style C or P base. Motor frame, brackets, canopy cap and outlet box are heavily ribbed, normalized cast

iron. Normalizing eliminates internal molecular stresses, resulting in distortion-free castings. Rotors are balanced, and bearings are arranged for transverse lubrication to insure complete purging of old grease. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif.

Circle 477 on page 19

Shut-Off Valves

for high-pressure oil and air service

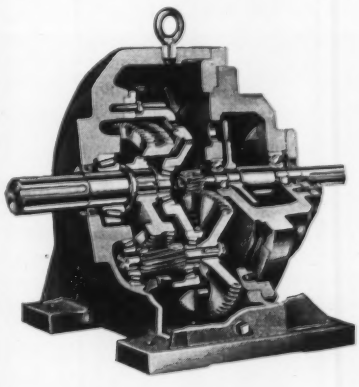
For controlling flow of oil to 3000 psi, and air to 2000 psi, manual shut-off valves will withstand velocities up to 60 fps without modification. Valve is opened or closed by turning hand-wheel through 90

New IN-LINE
Speed Reducers...

FLEXIBLE...
ECONOMICAL...
EFFICIENT

The streamlined compactness of these new units makes them ideal for mounting in places where space is limited. Accurately manufactured helical gearing, rugged housing construction and precision mounted shafts and bearings assure long, dependable service, with a minimum of maintenance. The *new* Phillie Gear "IN-LINE" Reducers are available in 18 different sizes and gear reductions to suit most types of service. Available for mounting in various positions . . . Standard AGMA ratios from 1.25:1 to 205:1.

Send for illustrated Literature describing these money-saving Speed Reducers.



phillie gear®

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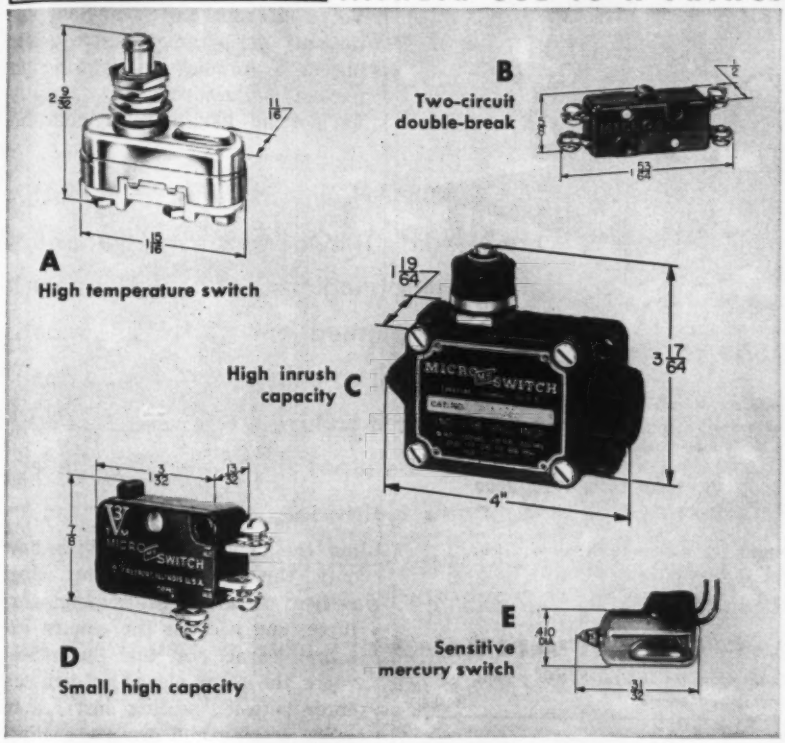
INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID MIXERS • FLEXIBLE COUPLINGS

Virginia Gear & Machine Corp. • Lynchburg, Va.

Circle 594 on page 19

MICRO *precision switches*

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN



A continuous flow of Precision Switch developments anticipates designers' needs

Whatever your requirements for an extremely reliable precision switch, there is—or can be—a MICRO SWITCH product to meet it. It makes no difference whether your switch must control sensitive electronic devices, instruments or heavy automatic machinery. Experienced designers save time and money by checking with MICRO SWITCH—pioneer manufacturer of precision switches.

Illustrated are a few examples of the wide range of MICRO SWITCH units to meet design requirements. These include hermetically sealed switches, switches for control of multiple circuits, switches resistant to high temperatures, heavy duty switches with high electrical capacity and very small switches —all for extremely precise operation.

A • High temperature switch. This switch will operate satisfactorily in a temperature range of from —50° F to plus 1000° F. Originally designed for use in jet aircraft applications, on or near the after-burner, the switch is equally useful for industrial applications which require high temperature components.

B • Two-circuit double-break switch fills the need for a small, two-circuit double-break switch for controlling two isolated circuits. This allows greater flexibility and simplicity of circuit design. A snap-action spring provides quick make and break of both circuits in each double-break circuit.

C • High capacity, sealed plunger switch. Compact, easy to mount precision snap-action switch which combines long life and reliability with the capacity to make and break steady state currents of 20 amperes and to handle inrush currents as high as 75 amperes.

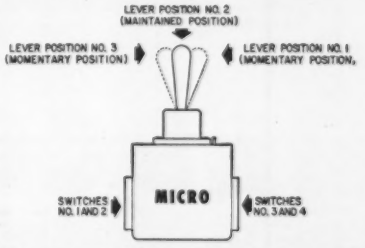
D • V3 small, high-capacity switch: MICRO V3 switches have extremely high electrical capacity for their size. They were developed to meet exacting design requirements for an extremely small switch with no sacrifice of quality. V3 switches are available with a wide variety of circuit arrangements, operating characteristics and actuators.

E • Sensitive mercury switch with ¼° operating angle. Small Honeywell Mercury Switches are designed to meet the demand of small load circuits and applications where space and economy are critical factors. Ratings may often be extended successfully down to microvolt milli-ampere ranges.

NEW!

An "Electrical Memory" Toggle Switch

Here is the first in a new series of "electrical memory" toggle switches. It is a four-pole assembly with one pole to indicate which circuit was last operated. It promises to simplify and perhaps revolutionize some basic circuit designs of complicated ground radar units, computer devices, aircraft control panels and other types of remote control equipment.


LEVER POSITION NO. 2 (MAINTAINED POSITION)
LEVER POSITION NO. 3 (MOMENTARY POSITION)
LEVER POSITION NO. 1 (MOMENTARY POSITION)
SWITCHES NO. 1 AND 2
MICRO
SWITCHES NO. 3 AND 4

	Lever Position No. 1	Lever Position No. 2	Lever Position No. 3
Switch No. 1	N.O. To C. Circuit Made	N.C. To C. Circuit Made	N.C. To C. Circuit Made
Switch No. 2	N.O. To C. Circuit Made	N.C. To C. Circuit Made	N.C. To C. Circuit Made
Switch No. 3	N.C. To C. Circuit Made	N.C. To C. Circuit Made	N.O. To C. Circuit Made
Switch No. 4	N.C. To C. Circuit Made	*	N.O. To C. Circuit Made

*N.C. To C. Circuit Made if Lever Last Moved To Lever Position No. 1
*N.O. To C. Circuit Made if Lever Last Moved To Lever Position No. 3

The assembly uses three single-pole, double-throw functional basic switches and one single-pole, double-throw "memory" switch.

In application the "memory" switch indicates through a pilot light or buzzer which circuit was last operated.

The three functional switches operate at three lever positions: maintained center and momentary from each extreme position.

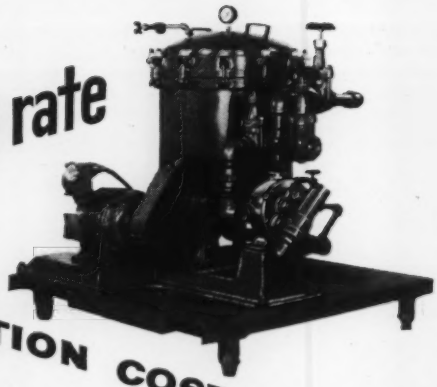
Electrical rating of basic switches: 5 amperes 125 or 250 volts a-c. The d-c rating at 30 volts: inductive—3 amperes at sea level and 2.5 amperes at 50,000 ft.; resistive—4 amperes at sea level and 4 amperes at 50,000 feet; maximum inrush—15 amperes.

For complete information on any of these switches or the complete MICRO SWITCH *line, call the* MICRO SWITCH *branch near you.*

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS



HIGH Flow rate

LOW OPERATION COST

WITH VIKING PUMPS

Sparkler Manufacturing Company, Mundelein, Illinois, assures high quality performance, high flow rate, and low operation cost by including Viking Pumps as original equipment on their horizontal plate filters for clarifying resinous coatings.

Filters range in capacity from 300, 500, 700, 1000, 1400, 1700, 2000 and 3000 gallons per hour, and Viking pumps are available in the sizes required to meet all of these capacities.

Vikings are adaptable to many pumping requirements—perhaps yours, too.

For information, write for Bulletin 565 h.

VIKING PUMP COMPANY

Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps

See our catalog in Sweets

Circle 596 on page 19

ILSCO THE BIG LUG OF INDUSTRY

For Superior Quality

√ Check these features

- ☐ Pure copper, 100% conductivity
- ☐ Wide wire range—re-usable
- ☐ U/L-CSA Approved
- ☐ Compact—rugged
- ☐ Advanced designing
- ☐ Sound engineering
- ☐ Speedy installation
- ☐ Cool operation—takes overload
- ☐ No special tools needed
- ☐ All screws wax-treated for better clamping

MODEL LO

ALL THESE FEATURES AT LOW COST

Your √ Test Will Prove ILSCO Superiority Over Cast Or Any Other Type Lugs

Write for Catalog #50 and Samples

ILSCO CORPORATION

5752 MARIEMONT AVE. CINCINNATI 27, OHIO

Circle 597 on page 19

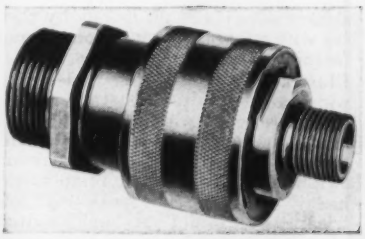
New Parts

deg, and has position indicator. Valve incorporates Shear-Seal rotor and seal arrangement, consisting of a tubular sealing ring in perfect contact with an optically flat porting disk, or rotor, containing the flow passage. With flow only through the sealing ring, rather than across sealing surfaces, and because the square external corner of the Shear-Seal wipes the rotor clean, no dirt can enter between sealing surfaces to cause scoring and destroy sealing. Valves are available in pipe sizes of ¼-in. through 1 in. NPT. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 478 on page 19

Quick-Disconnect Coupling

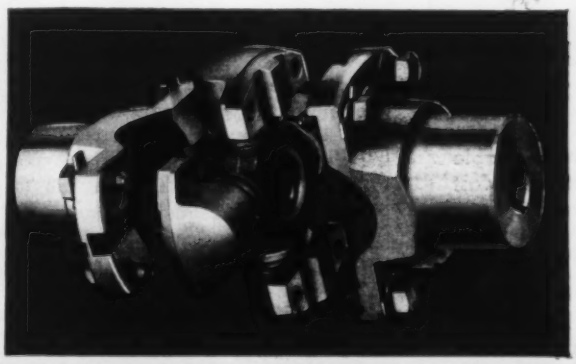
may be disconnected under 60 psi pressure



A fast-acting, self-sealing hydraulic coupling may be locked or unlocked against 60 psi pressure in both coupling halves with a simple push or pull. Disconnection and sealing of both halves is instantaneous and positive, yet high acceleration and impact loads will not cause accidental uncoupling. Coupling exceeds military specifications for air-inclusion, oil loss, and pressure drop and is rated to 3000 psi. Operating sleeve stays

SPECIFY KEY-DRIVE JOINTS FOR **FAST** ASSEMBLY AND SERVICE OPERATIONS

Unique features of MECHANICS Roller Bearing UNIVERSAL JOINTS make them unusually easy to install and service. The complete cross and bearing assembly can be removed simply by taking out the cap screws and separating the end yokes slightly. No flange is required for drive shaft connections. Accurately and durably built for long, heavy service, MECHANICS Roller Bearing UNIVERSAL JOINTS are inherently balanced for smooth operation.



Let our engineers show you how MECHANICS close-coupled Roller Bearing UNIVERSAL JOINTS conserve space and compensate for offset shafts, in your new and improved models.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.
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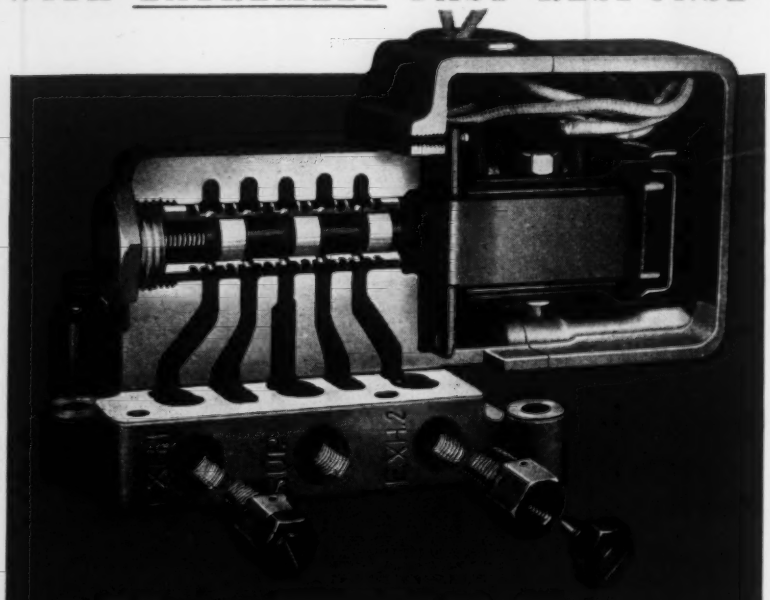
MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

Circle 598 on page 19

now . . . AIR VALVES

WITH EXTREMELY FAST RESPONSE



. . . Almost TWICE As Fast As Ordinary Valves!

The new SA Series single solenoid actuated valves are available in both single and dual pressure models with extremely fast response time. You get total response in 12 *milliseconds*—from energizing to wide open on 60 cycle current. That's almost *twice as fast* as any pilot operated solenoid control valve available today!

All SA Series valves are high performance, full pipe area valves . . . furnished for service on vacuum and air at pressures from atmospheric to 250 psi . . . and at speeds from the most intermittent job in your plant to welding guns. Optional metering valves give simple, sensitive control of piston speed by metering the exhaust air. Exhaust noise is muffled.

The design simplicity of the SA Series valves provides extremely long life and requires a real minimum of maintenance. Only one moving part provides the valving action . . . a corrosion-resistant steel spool and sleeve.

Complete information on the SA Series valves . . . the greatest advance in air controls . . . can be obtained by writing today for your copy of Catalog 8000.

NUMATICS, Inc.

MILFORD, MICHIGAN • DEPT. MD

Circle 599 on page 19

New Parts

in assembled position under repeated acceleration of 35 *g*, and may be inspected by sight or feel. The coupling has locking device and sealing elements located internally, thus avoiding damage, and is equipped with standard fittings and bulkhead flange. **Weatherhead Co.**, Aircraft Div., Antwerp, O.

Circle 479 on page 19

Hermetic Variductor

miniature unit is 25/32-in. by 1⅛ in.

Miniature hermetic variductor designed to meet Mil-T-27 specifications, provides high Q, has high voltage and temperature stability, and shock and vibration resistance.

Adjustment of set screw on case permits varying inductance from plus 200 per cent to minus 70 per cent of mean value. Twelve types cover inductances from 2 mh to 500 h, and frequency ranges of 50 to 10,000 cycles. **United Transformer Co.**, 150 Varick St., New York 13, N. Y.

Circle 480 on page 19

All-Metal Mount

isolates low-frequency vibrations

Mount successfully isolates vibration from airborne electronic equipment in applications involving low-frequencies and high excursions. All-metal unit is of Bellville spring type, consisting of two load-carrying convex springs, a circular coil spring and wire mesh pads. Mount is captivated, available with short or long studs, and in load ranges from 3½ to 28 lb. Providing some shock control, the mount has low natural frequency, ranging from 4 to 4.5 cps,

AVOID the **HIGH COST** and difficulty of fabricating long, hard & straight parts by conventional methods . . .

THOMSON

60 Case

hardened and ground

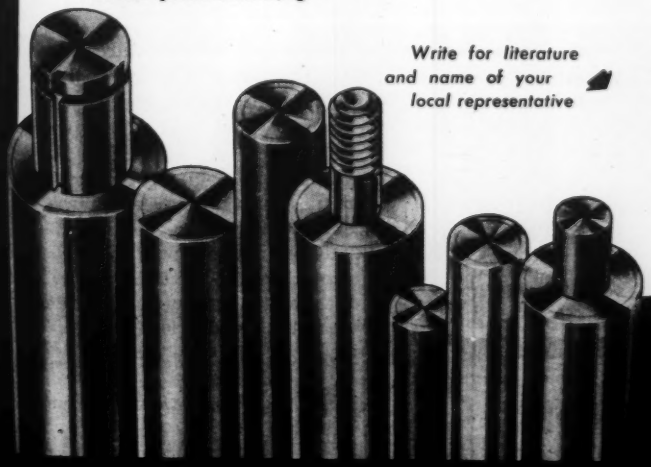
SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.



Write for literature and name of your local representative

ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

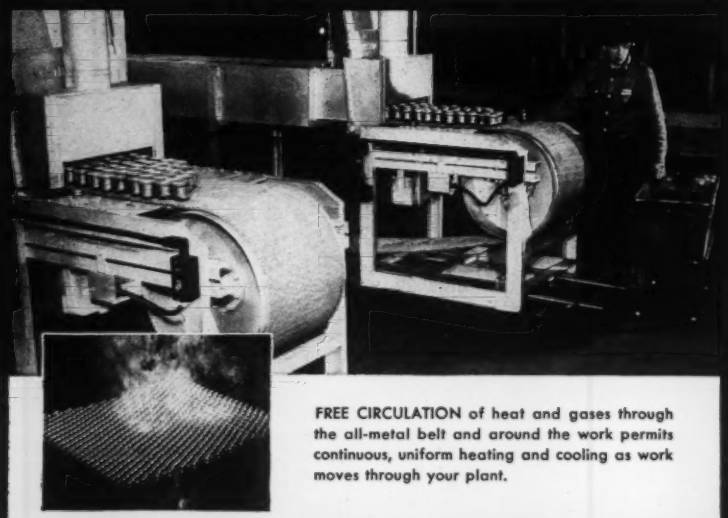
GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

THOMSON INDUSTRIES, Inc.
Dept. C5, Manhasset, New York

Circle 600 on page 19

Cambridge

WOVEN WIRE CONVEYOR BELTS take the "hot spots" out of ANNEALING & BRAZING



FREE CIRCULATION of heat and gases through the all-metal belt and around the work permits continuous, uniform heating and cooling as work moves through your plant.

By combining controlled movement with free circulation of process atmospheres, Cambridge Woven Wire Conveyor Belts eliminate batch annealing and brazing. There is no formation of "hot spots" which produce local stresses. Continuous, belt-to-belt flow through subsequent quenching and washing operations as well as heating, cuts costs and provides fast, uniform production.

REGARDLESS OF YOUR INDUSTRY...

. . . metalworking, food, chemical, glass and ceramic . . . whether the machines are for your own operation or resale, you'll find "free circulation" only one property of Cambridge belts that makes combined movement and processing practical and economical. Open mesh construction also provides rapid drainage of process solutions. Belts are corrosion resistant and impervious to heat damage, even at 2100°F. They have no seams, lacers or fasteners to wear more rapidly than the body of the belt. Cambridge Woven Wire Belts are made in any size, mesh or weave; from any metal or alloy. Special surface attachments are available to hold products during inclined movement.

Call in your Cambridge FIELD ENGINEER to discuss how you can cut costs by continuous operation. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

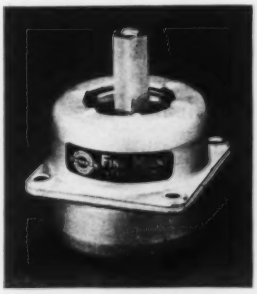
WIRE CLOTH · METAL CONVEYOR BELTS · SPECIAL METAL FABRICATIONS

Department N, Cambridge 9, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Circle 601 on page 19

New Parts

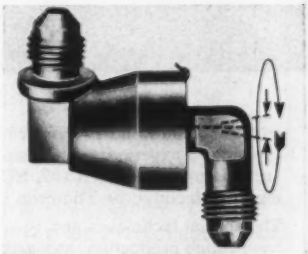


a large deflection, and takes extremely high excursion (¼-in. peak-to-peak load) with magnification factor of 1.8 or less at resonance. Used in applications involving low speed rotating components and rapid altitude changes, the mount is capable of use in helicopters. **T. R. Finn & Co. Inc.**, Electronics Div., 200 Central Ave., Hawthorne, N. J.

Circle 481 on page 19

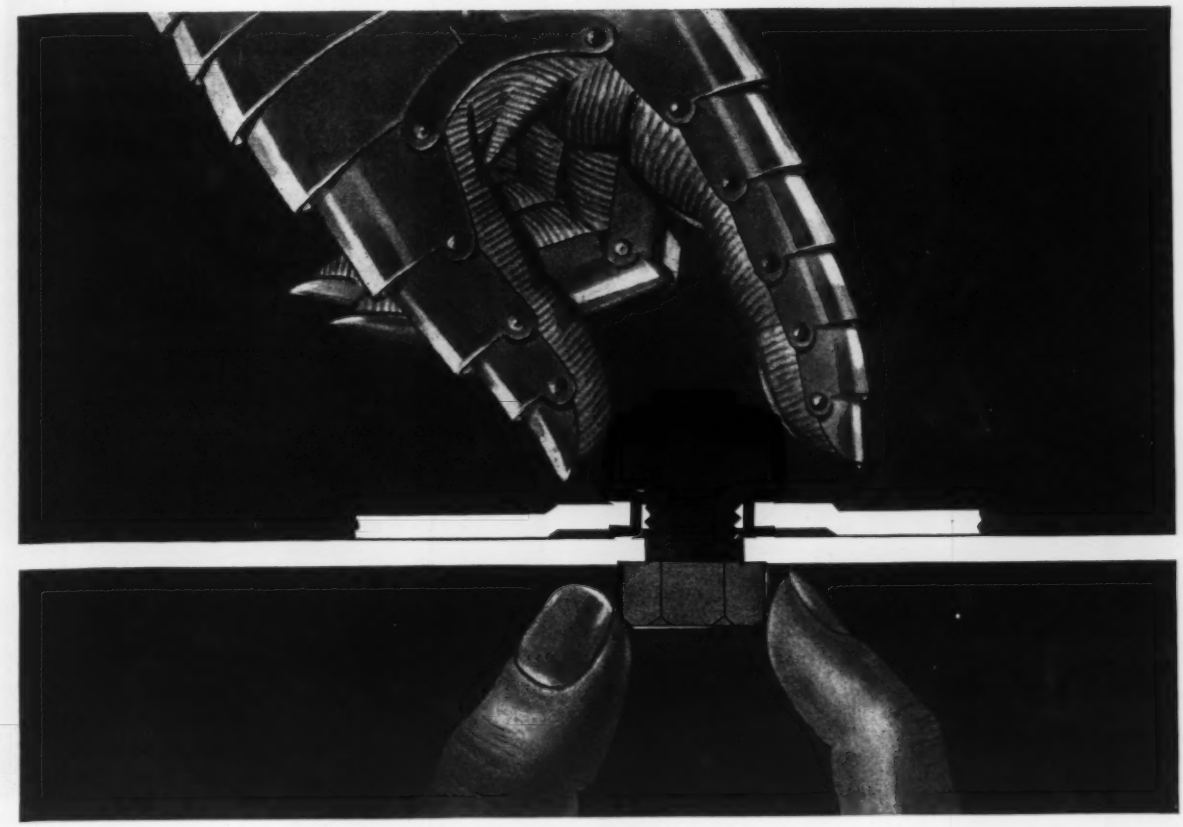
Swivel Joints

withstand pressures to 4000 psi



Compact aircraft-type swivel joints conforming to Mil-J-5513A and other specifications are for use in airborne equipment, track vehicles, and similar applications. Two basic types are available with AN flared or ERMETO ends in aluminum, steel, and stainless steel for pressures up to 4000 psi. Units are operable in temperatures from −300 F to +700 F for service with hydraulic fluids, air, oxygen, fuel, steam, and acid. The plane swivel joint, incorporating ball bearings, gives 360-deg rotation in a single fixed plane, at starting torque of five inch-pounds. The self-aligning swivel joint gives 360-deg rotation and absorbs vibration and misalignment up to 15 deg. **Barco Mfg. Co.**, Barrington, Ill.

Circle 482 on page 19



FINGERS OF STEEL
that hold where you can't reach

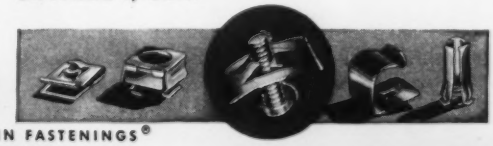
If you can't reach the back of a panel to hold a nut, let the spring steel fingers of a Tinnerman SPEED GRIP® Nut Retainer hold it for you. No welding or staking, no special skills or equipment required. It's the most efficient way to attach a square nut to a panel in blind location.

The SPEED GRIP combines a square nut retained in a spring steel cage. The SPEED GRIP snaps easily into the panel. Expensive rigid position methods are eliminated. Nut floats free in the cage to offset minor hole misalignments, but cannot turn as bolt is tightened.

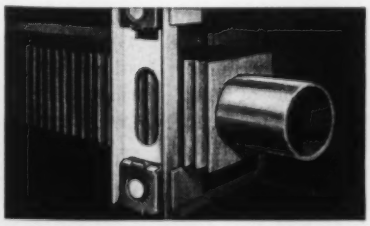
SPEED GRIPS can be put on anywhere along your assembly line . . . no side trips to special stations, no line deviations of any kind. Rustproofed, they can be applied after painting, ending costly masking or retapping of paint-clogged threads.

Consult your Tinnerman representative soon and write for Bulletin No. 335. **Tinnerman Products, Inc., Box 6688, Department 12, Cleveland 1, Ohio.**

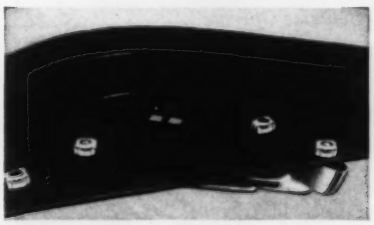
TINNERMAN *Speed Nuts*



FASTEST THING IN FASTENINGS®

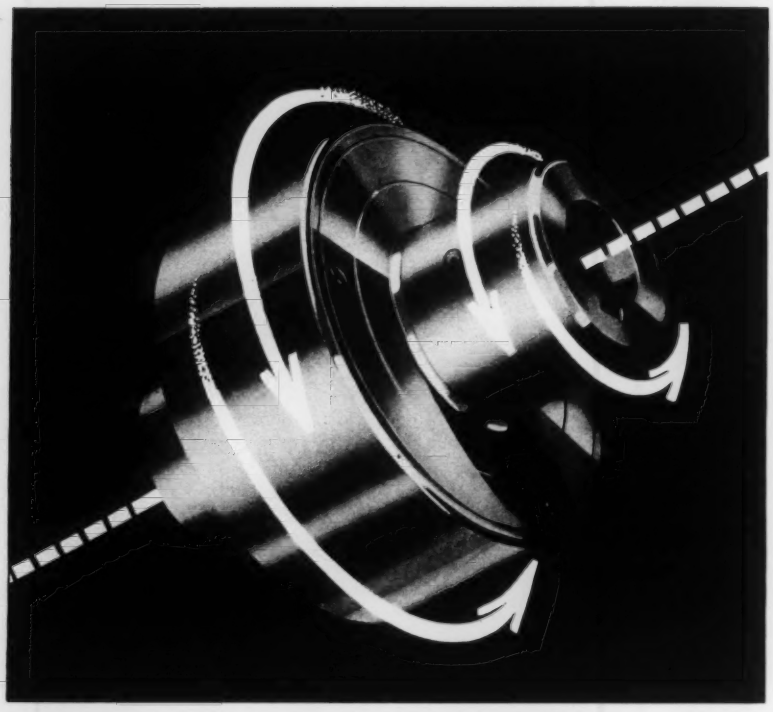


SPEED GRIPS eliminate several punched and tapped holes, cut assembly costs 78%, simplify installation of heater.



SPEED GRIPS applied *after* painting simplify blind-location assembly of auto seat handle, avoid paint-clogging of threads.

SPEED GRIPS cut costs 75% by replacing tapped holes and weld-type nuts as mounting fasteners on car radio.



Why a "CENTRIC" is right for *any* power drive

. . . a Centric Clutch or Clutch-Coupling

. . . . right because there's a "Centric" to exactly meet every power drive requirement regardless of type of drive or capacity, from fractional to 2500 H.P. for direct motor drives—dual and engine drives—indirect drives.

. . . . right because every Centric Centrifugal Clutch-Coupling and Clutch has been expertly designed for simplicity, sturdiness and operational efficiency—simplicity and close tolerances of working members for negligible wear—sturdiness to assure a long useful life—for operational efficiency so that power drives are smooth and gradual without shocks—so that running loads are accelerated and controlled.

. . . . right because "Centrics" save money on motor drives. Motors can be selected for running rather than starting loads thus permitting higher efficiency and lower power factor.

For full details on "How Centrics Operate", their construction, advantages and the complete line, send for Bulletin #301.

CENTRIC *Clutch Company*

P. O. BOX 175 • U. S. ROUTE 9 AT MAIN STREET • WOODBRIDGE, NEW JERSEY

Circle 603 on page 19

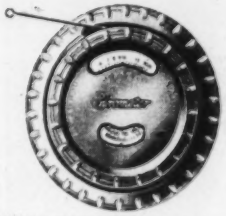
ENGINEERING DEPARTMENT

EQUIPMENT

Pocket Tachometer

interprets vibrations as rpm

In use, this tachometer is placed on housing of running motor, generator, or other rotating machinery. A disc is turned, extending the indicator wire. When the wire reaches the resonance point, rpm



and cps are read directly on the scales. Rotational speed range is 800 to 25,000 rpm. **Precision Instrument Service,** 301 Franklin Ave., Franklin Square, N. Y.

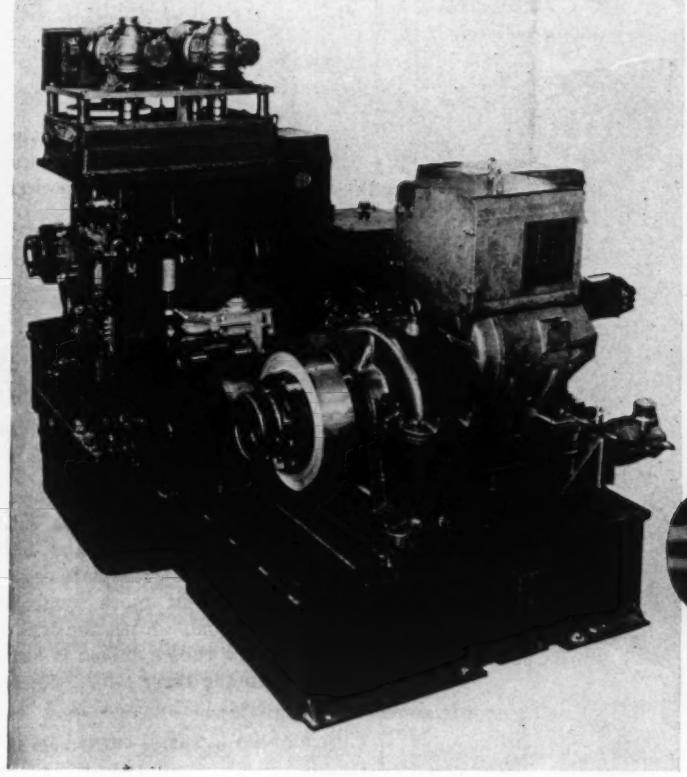
Circle 483 on page 19

Dynamometer Scales

measure either push or pull forces

Available in capacities from 1 to 600 lb, this dynamometer has general application in spring, torque and dynamometer testing. Construction of unit permits either push or pull forces to be measured on the same shaft. It can be mounted vertically, shaft down, or horizontally; provisions for vertical mounting with shaft up can be provided on special order. Di-

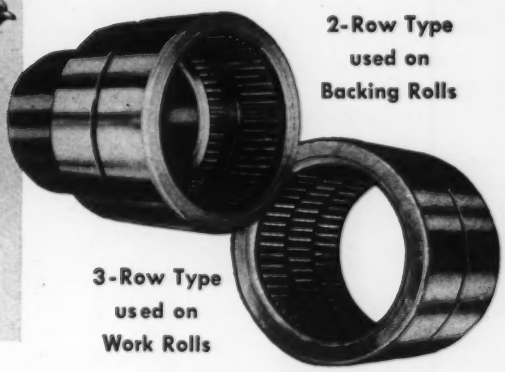
RUESCH 4-High Rolling Mill holds gauge tolerance of ±.0001″



Model 210 4-High Rolling Mill, manufactured by H. J. Ruesch Machine Co., Newark, N. J.

Another successful installation of

ORANGE
Cage Type
NEEDLE BEARINGS



2-Row Type used on Backing Rolls

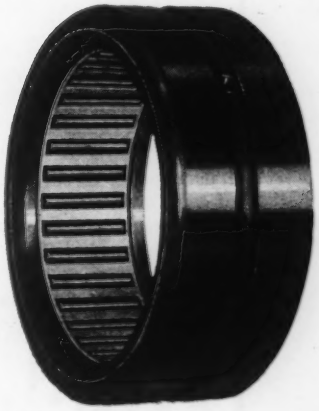
3-Row Type used on Work Rolls

The performance and precision of the Ruesch 4-High Rolling Mill are outstanding. It cold rolls ferrous and non-ferrous strip up to 12″ wide, in thicknesses up to .090″, at speeds up to 500 fpm., and automatically holds a gauge tolerance of plus or minus .0001″.

Ruesch reports that "Orange Cage Type Needle Bearing provide the highest capacity for a given size, which permits maximum roll journal diameter, resulting in greater rigidity of mill construction and improved precision".

Here's the reason: The Orange cage design combines the high load capacity and compactness of needle bearings, with the precision running of cage-retained rollers which are permanently aligned, can not skew. They are true running in any position—extremely even, quiet running—give long service life.

Orange Cage Type Needle Bearings are available in stock sizes from ½″ to 8″ shaft dia., interchangeable with all standard needle bearings. Write for new Engineering Manual M-56.



ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

INSTALL IT

FORGET IT!

. . . when it's a

WINSMITH Speed Reducer

Get acquainted with the Winsmith line of speed reducers that are installed and forgotten because they never call attention to themselves as trouble-makers.

Next time you want to cut your r.p.m's. down to size accurately, under the most rugged operating conditions, specify Winsmith . . . the line of speed reducers that can be described in just one word — *dependable!* You'll find that their performance adds to the reputation of your equipment.

And, as a source of supply, Winsmith offers the most complete line of reducers within the range of 1/100 h.p. to 85 h.p. in ratios of 1.1:1 to 50,000:1. For complete details write for Catalog 155, described below.

WINSMITH SPEED REDUCERS

GET THE FACTS!

Catalog 155 describes the *new* "C" Series plus other units in the Winsmith line. Contains complete selection information for each model described.

WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

Circle 605 on page 19

Engineering Equipment

ameter of scale face is 15 in. **John Chatillon & Sons,** Spring Div., 85 Cliff St., New York 38, N. Y.

Circle 484 on page 19

Electrical Symbol Template

speeds drawing of new American Standards symbols

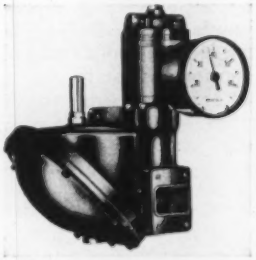
Leroy symbol-drawing templates give new and revised electrical symbols, prepared by American

Standards Association, in three sizes: same size as standards bulletin, 50 per cent larger and 100 per cent larger. Template contains 60 per cent more symbols than obsolete one. A set for drawing electronic tube symbols is also available in the three sizes. **Keuffel & Esser Co.,** Hoboken, N. J.

Circle 485 on page 19

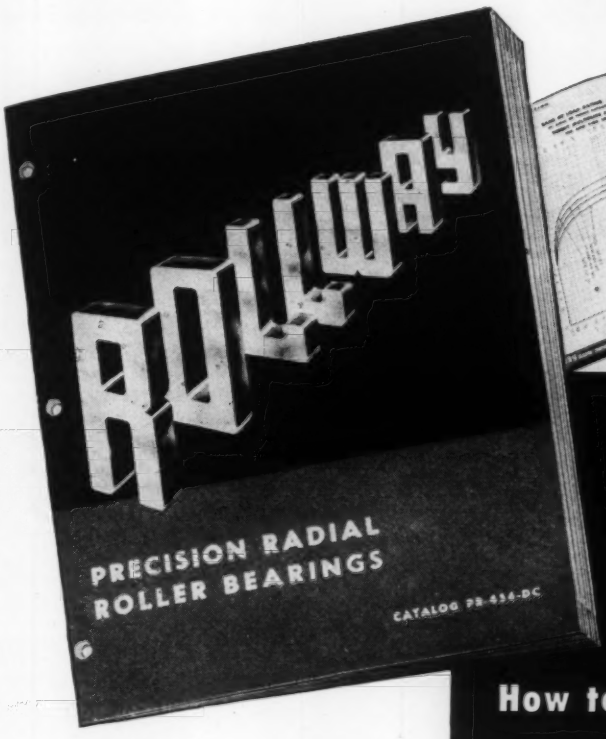
Pressure Transmitter

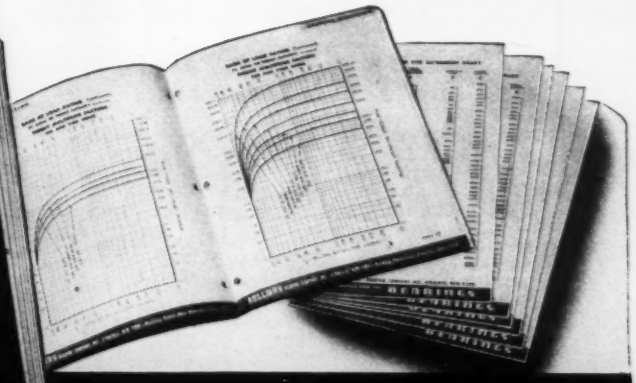
converts low pressures to high-pressure signals



A Metagraphic absolute pressure transmitter for use in pneumatic transmission instrument systems measures pressures as low as 0 to 5 mm mercury absolute. It transmits the measurement as a 3 to 15 psi pneumatic signal to an automatic controller or standard receiver. The unit handles pressure ranges to 760 mm Hg, maximum. **Bristol Co.,** Waterbury 20, Conn.

Circle 486 on page 19





NEW Rollway Catalog & Engineering Data Book

Chock-Full of Useful Information on How to Select ROLLER BEARINGS

- **Reflects latest RBEC* standards and formulas, PLUS the latest research of Rollway engineers.**
- **Contains the following important data on precision radial roller bearings . . .**

CAPACITIES Detailed information on radial static capacities, radial dynamic capacities, and thrust capacities of cylindrical radial bearings.

Thrust capacities and radial dynamic capacities are given separately. Thrust load does *not* reduce radial capacity nor life expectancy of bearing: It is not necessary to calculate an "Equivalent Radial Load."

APPLICATIONS Load ratings, radial internal clearances temperature allowances, provision for float, alignments, seals, lubrication, etc. . . . all are thoroughly covered, supplemented by engineering drawings of typical applications.

NOMOGRAMS The RBEC* formula is here converted into simple nomogram charts, eliminating complicated selection procedures. You can find in seconds the proper bearing for your application.

PRECISION TABLES Detailed data shows the tolerances achieved with varying degrees of precision. Complete tables include limits for shaft diameters and housing bores to obtain proper type of fit of inner and outer races for various operating conditions.

*Roller Bearing Engineers' Comm.—Anti-Friction Bearing Mfrs. Assn.

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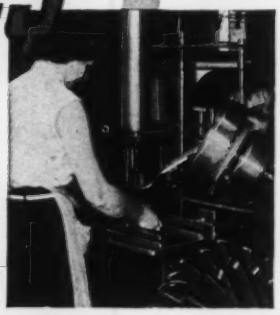

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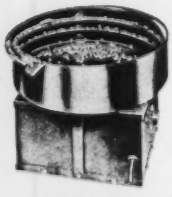
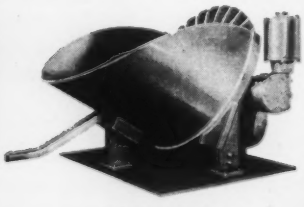
● Stepped-up output . . . time saving . . . lower costs . . . Combine them . . . What do you get? A rise in profits. It's today's industrial challenge, and DPS POWER SCREWDRIVERS and SELECTIVE PARTS FEEDERS meet it effectively . . . plus the added advantages of uniform, better work, without interruption and the excessive cost of hand methods . . . More than 12,000 successful applications in progressive plants everywhere prove it . . . It lends assurance that we can meet your requirements. Write us . . . Tell us your set-up . . . We'll make recommendations.

5 SCREW-DRIVING MACHINES
Bench and Pedestal types. Pedestal Model A pictured



BOWL FEEDER
Vibratory type, to select and feed smaller fragile parts



BARREL FEEDER
with stationary ring cover, for heavy-duty, large production runs

DETROIT POWER SCREWDRIVER CO.
2801-A W. FORT ST. DETROIT 16, MICH.

Circle 607 on page 19

THE ENGINEER'S Library

Recent Books

Theory and Practice of Lubrication for Engineers. *By Dudley D. Fuller, professor of mechanical engineering, Columbia University; 432 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$10.50 postpaid.*

Purposes of this book are to present the theory of lubrication to the engineer in a usable form, to systematize and generalize the basic concepts of lubrication, and to demonstrate the usefulness of lubrication analysis. Considerable emphasis has been given to hydrostatic lubrication. Chapters cover: fundamentals and variables of lubrication, hydrostatic squeeze films, hydrodynamic lubrication, typical industrial bearings, air-lubricated bearings, dry friction, boundary friction and bearing materials.

♦

Engineering Mechanics, 4th Edition. *By S. Timoshenko, professor emeritus of mechanical engineering, and D. H. Young, professor of mechanical engineering, both of Stanford University; 529 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

The purpose of this text is to provide training in the fundamentals of mechanics and to illustrate methods of attacking engineering problems. Revisions in this fourth edition are: simplification of the text, improved arrangement of subject matter, and de-emphasis of algebraic treatment of problems. Two major parts comprise the book. The first, statics, includes chapters on force systems in space and the principle of virtual work. The second part, dynamics, includes chapters on

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4 times as many burner grills per hour

Bending metal rods for kerosene burner grills requires a ton of force at Barridon Oil Burner Corporation in Hartford, Connecticut. Before air was adapted to the job, only 150 pieces per hour could be produced. Now, with the help of Schrader Air Products, 620 pieces are produced every 60 minutes.

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Schrader engineering facilities are available to help you. Upon request, Schrader engineers will assist in planning for the most efficient use of air in your plant. Outline your problem to us and we'll give you prompt help. Right now—send for the latest informative booklets which show Schrader Air Products that can increase production, at low cost.

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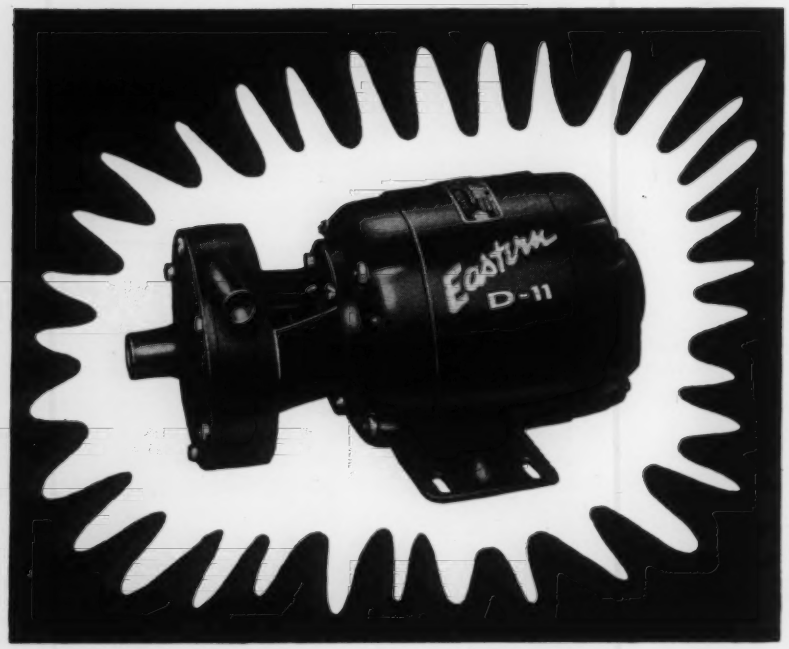
FIRST NAME IN THE USE OF AIR
FOR INDUSTRIAL PRODUCTION AND CONTROL

Circle 608 on page 19



24,830 successful installations!

EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-G

Eastern INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

Circle 609 on page 19

The Engineer's Library

rectilinear translation, curvilinear translation and relative motion. Three appendixes treat moments of inertia and forced vibrations.

New Standards

Product Standards for Die Castings. 8½ *by* 11 *in., loose leaf pages; published by and available from American Die Casting Institute Inc.,* 366 *Madison Ave., New York* 17, *N. Y.; ADCMI-M-series, introduction and one-page standards as follows:*

M1-55T **Alloy Cross Reference Charts**
M2-55T **Composition and Properties of Standard Aluminum Base Alloy Die Castings**
M3-55T **Composition and Properties of Special Aluminum Base Alloy Die Castings**
M4-55T **Characteristics of Aluminum Alloys**
M5-56T **Composition and Properties of Copper-Base (Brass) Alloy Die Castings**
M6-56T **Brass Die Castings and Alloy Selection**
M7-56T **Composition and Properties of Magnesium Base Alloy Die Castings**
M8-56T **Characteristics of Magnesium Alloy Die Castings**

Prepared as guides to engineers and designers, these standards are intended to promote economical production by preventing specification of unnecessarily critical conditions.

Association Publications

1956 Collected Technical Papers. 524 *pages,* 8½ *by* 11 *in., paperbound; published by and available from American Society of Tool Engineers,* 10700 *Puritan Ave., Detroit* 38, *Mich.;* $4.00 *per copy to ASTE members;* $7.50 *per copy to nonmembers.*

This volume contains 51 lectures and a panel discussion presented at the 24th annual convention of the ASTE, two Research Fund reports, and a summary of the ASTE Automation Survey. Representative subjects covered are: ceramic tooling, silent-sound and electrical-discharge machining, automation, electronic calculators, laboratory research in conjunction with production machining and the training of engineers.

♦

Proceedings, Second General Assembly, Engineers Joint Council. 68 *pages,* 8¼ *by* 11¼ *in., paperbound; published by and available from Engineers Joint Council,* 29 *West* 39*th*

St., New York 18, *N. Y.*; $1.00 *per copy.*

Transcriptions of 21 talks and several discussions delivered at the assembly in January 1956 are included in these proceedings. Three talks concern the Reserve Forces Act of 1955, eight pertain to the extension of engineering manpower by utilizing balanced teams of engineers and technicians, five concern the growth pattern of the engineer, and two review the engineering aspects of the Hoover Commission reports.

Manufacturers' Publications

Report on the Application of Plastics to Roller and Ball Bearings. 115 *pages, 8½ by 11 in., paperbound; published by and available from Kaydon Engineering Corp., Dept. PB, McCracken St., Muskegon, Mich.;* $4.75 *per copy.*

This report covers a government project to determine the best types of plastics for use as rolling elements in large-size, heavy-duty bearings. For a number of different plastics, the report gives testing procedures used, testing evaluations, comparative merits of plastic ball materials, bearing design data, and graphs showing load vs. deflection for different diameter balls.

Government Publications

Development of Brazing Alloys for Joining Heat Resistant Alloys, PB 121001. *By Forbes M. Miller, Homer S. Gonser and Robert L. Peaslee, all of Wall Colmonoy Corp.; 73 pages, 8 by 10½ in., paperbound; prepared for Wright Air Development Center, U. S. Air Force; available from Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.;* $2.00 *per copy.*

Fifteen different alloy systems were tested for brazing characteristics and chemical and physical properties. The alloys studied were nickel-base binary and ternary systems containing silicon, chromium, manganese, and iron.

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Circle 610 on page 19

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WEIGHT ENGINEERS
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DYNAMICS ENGINEERS
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structures

Expansion within Northrop Aircraft's Structures Department is creating an urgent demand for qualified personnel in all phases of guided missile, piloted aircraft, and equipment development. Included among the most critical job openings are positions for:

Stress Department—Mechanical or Civil Engineers to design missile ground handling equipment. An opportunity for men without aircraft experience to take advantage of the aircraft pay scale.

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Loads—Exciting and diversified assignments in the fields of both piloted and pilotless aircraft are now available in Structural Loads Group for engineers of all experience levels.

Stress Department—Experienced Structural Engineers for positions on Long Range Interceptor Project and on advanced missile designs.

A wide diversification of assignments within each field of specialization awaits the men capable of filling the above assignments. Responsibilities will include work on many phases of missile and aircraft design, guidance systems and boundary layer research.

If you qualify for any of these challenging opportunities, we invite you to contact Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., 1016 East Broadway Hawthorne, California, or call ORegon 8-9111, Extension 1893.

NORTHROP AIRCRAFT, INC.

PIONEERS IN ALL WEATHER AND PILOTLESS FLIGHT

5-A-49-B

New Machines

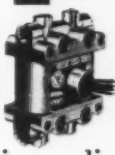
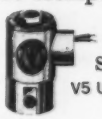
Materials Handling

Fork Trucks: Clarklift fork lift trucks have a 12-v electrical system, fully automatic transmission, emergency fuel tanks, foam rubber seats and automobile-type controls. Design also incorporates self-adjusting brakes, balanced swing-up hood, solid-tire models with drive and steer wheels of the same diameter, combination lift-tilt controls on the steering column, optional radiator screens for dusty operations, deep-tapered forks, chrome-plated air scoops framing the driver's seat, and a swept-back counterweight. Pneumatic-tire models, designated Super Yardlifts, are designed for rugged outside work. They have powerful engines, high underclearance and drive wheels the same diameter as steer wheels. Tubeless, high flotation tires are available with pressures of 30 or 75 psi, and are interchangeable on each Yardlift model. All trucks are available in gas models with capacities from 2000 to 5000 lb. Solid-tire models have a minimum full-load speed of 8 mph and gradeability of 20 to 30 per cent. Pneumatic-tire models have a full-load speed of 12 mph and gradeability of 26 to 33 per cent. *Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich.*

Lift Trucks: Series of pneumatic-tired units with capacities of 3000, 4000 and 5000 lb are gasoline-powered and have automobile-type controls. Trunnion steer wheels, short overall length and short turning radius are design features which provide high maneuverability. Design also incorporates long wheelbase, low center of gravity and low seat height. Brakes are self-energizing in both directions with a total of 125 sq in. braking area. Interlocking rolled channel uprights with open-view provide good operator visibility. Load lifting speeds are 48 fpm for the 5000-lb

Circle 611 on page 19

25,000,000 CYCLES*

Skinner solenoid valves  are ideally suited for use in high-speed production lines. They perform lubricating, cylinder control, blowing and ejecting functions in hundreds of applications, such as drilling stamping, pressing and riveting. Skinner valves provide fast, dependable and trouble-free operation. They're leakproof, rugged, and *simple to inspect.* Available in more than 100,000 variations,  so you're sure of finding the valve that is perfect for *your* particular application.

V9 Four-Way

V5 Universal

Call in a Skinner engineer *first* to help you with your solenoid valve problem. With us, no problem is too great, no quantity is too small. Write for Skinner's new solenoid valve catalog . . . on your letterhead, please.

*Special Skinner solenoid valves have proven operable up to 25,000,000 cycles in specific applications.

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SKINNER ELECTRIC VALVES

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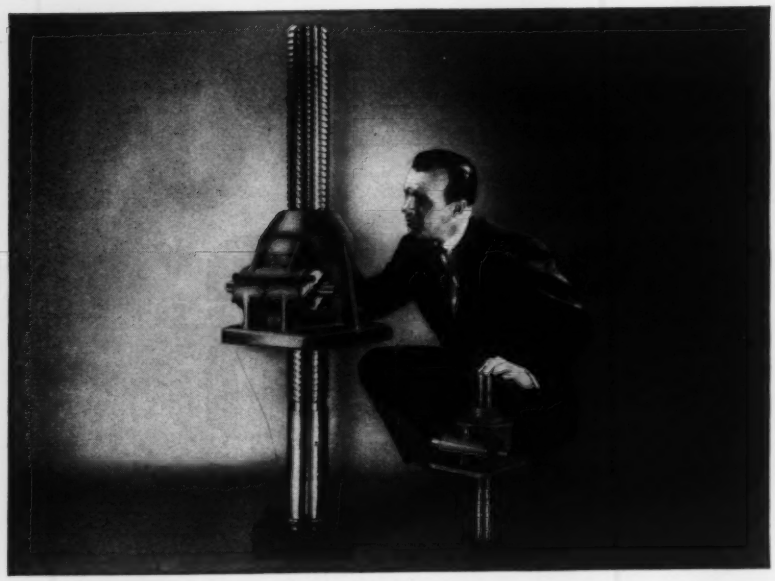
WORLD-WIDE REPRESENTATION

Circle 612 on page 19

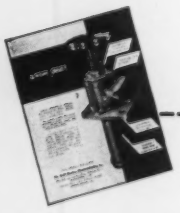


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 96:1; turn of worm for each 1-inch raise, 10 to 180; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.



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COMPANY _____ PHONE _____

ADDRESS _____

Circle 613 on page 19

New Machines

capacity model and 50 fpm for the 3000 and 4000-lb models. Forward travel speed is 13.8 mph in all models. Constant mesh transmissions provide quiet operation and ease in shifting. Heavy-duty industrial engine has high torque and high-capacity liquid cooling system. Cantilever swing-up engine hood fully exposes internal mechanism for quick service. Power steering, fluid torque converter drive, LP-gas installation, dual front wheels, overhead guard and Free Lift are optional. *Hyster Co., Portland, Oreg.*

Metalworking

Press: Automatic 75-ton Flexopress has anti-friction ball-bearing raceway construction which makes possible long die life. The slide, with four preloaded, ball-bearing raceways operating in hardened and ground steel inserts, maintains vertical accuracy within 0.0005-in. and parallelism between slide face and bed within 0.0015-in. to prevent misalignment between punch and die. Low ram inertia permits operation at up to 370 strokes per minute. Ram construction is of lightweight aluminum alloy. Side opening of 15 in. accommodates work up to 14 in. wide. Automatic feed is infinitely adjustable to 8 in. per stroke. Stroke is standard 2½ in. With slide in down position, maximum distance between slide face and bolster is 10 in. Electric control, which can be installed in a console, pendant or machine-mounted panel, provides single stroke, continuous operation, inching, variable top stop control, variable sequence inch control, key locking, motor reverse, motor start, emergency stop, variable motor speed, key locking stroke counter and visible tachometer. The machine has a 10-hp adjustable speed drive, 220/440 v, 60 cycle, 3 phase, 1675 to 100 rpm. *Precision Welder & Flexopress Corp., Cincinnati.*

Centerless Grinder: No. 2C heavy-duty grinder is a standard centerless grinder for throughfeed work, a standard grinder for infeed work, and, equipped with a crush dressing attachment, it

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form grinds and does profile work. The unit finish grinds parts from solid or finish grinds rough turned parts. It will grind a variety of small parts made of metal, plastics and glass. Grinding wheel spindle is of a unit-type construction, is totally enclosed with double-row, precision bearings, sealed and lubricated for life. Main drive motor is 15 hp, 1800 rpm, and is totally enclosed and dynamically balanced. Wheel speeds are 10 to 57 rpm in the low range, and 60 to 355 rpm in the high range. *Van Norman Machine Co., Springfield, Mass.*

Shear: No. 31-RC shear cuts circles, circular holes and rings, as well as both straight line work and irregular outlines which do not require sharp curvatures. Having a capacity of 10 gage mild steel, it cuts circles from 6 through 78 in. in diameter. Self-compensating circle arm floats on guided ways to maintain true center automatically. Adjustable crank enables quick positioning of the circle arm for cutting circles of various diameters. Actuated by a quick-acting cam lever, the center clamp of the circle arm is adjustable to hold varying thicknesses of material securely at all times. Raising and lowering of the upper cutter is accomplished by the use of a hand wheel, permitting the cutting operation to be started at any point on the blank. High carbon, high chrome steel cutters assure clean, fast cuts. An adjustable swinging gage for centering unmarked blanks and an adjustable straight slitting gage are furnished. Motor is 3 hp, 1800 rpm. *Niagara Machine & Tool Works, Buffalo.*

Power Plant Equipment

Boiler: CB 200-hp self-contained boiler has full modulating burner, silent oil pump, and davited rear and front doors to expedite tube removal and cleaning. Caseless fan draws combustion air into a large plenum chamber which deadens noise. Controls are designed for ease of operation, maintenance and reliability and meet code requirements. Doors are sealed with pre-

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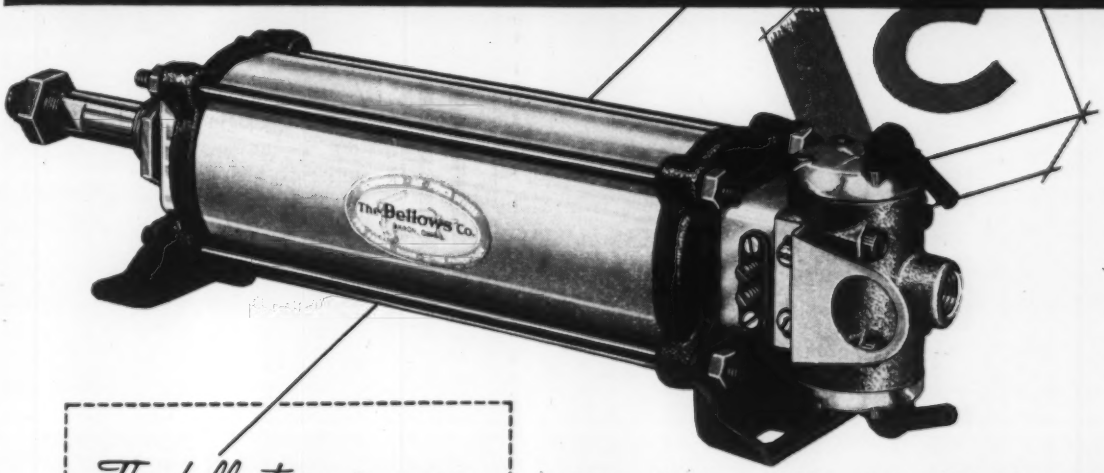

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Circle 616 on page 19

design data

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New Machines

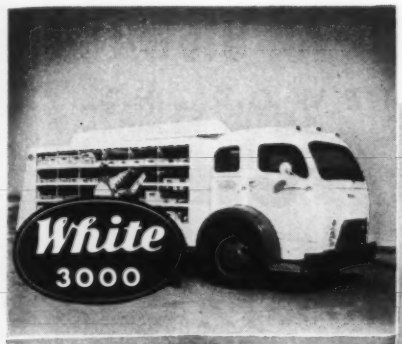
formed asbestos gaskets. Combustion air passes through the front head and keeps burner and control panel cool. Totally enclosed control panel, located at operator level, contains burner relay, blower motor starter and control switches. An assembly containing both the electric and steam preheater is encased in a single shell. Boiler is fiberglass insulated and covered with 16 gage metal lagging. It is offered in series 100, light oil; series 200, No. 2 oil and gas; series 400, No. 6 oil and gas; series 600, No. 6 oil; and series 700, straight gas. *Cleaver-Brooks Co., Milwaukee.*

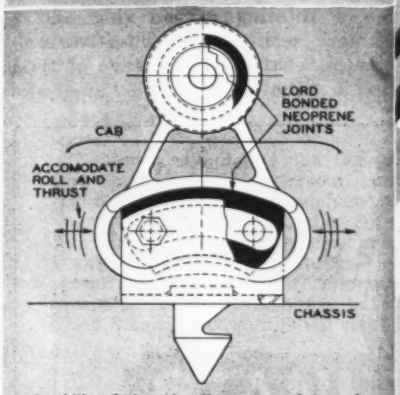
Diesel Engine: Model 17A 20-hp diesel engine is a two-cylinder unit; it has a 3½-in. bore, 4-in. stroke and 76.8 cu in. displacement. Fan to flywheel unit measures 26 in. high, 22¼ in. long and less than 17 in. wide. The engine is also available as an open power unit, standard power unit, closed power unit and as a 5 to 7½ kw generating set. *R. H. Sheppard Co. Inc., Hanover, Pa.*

Processing

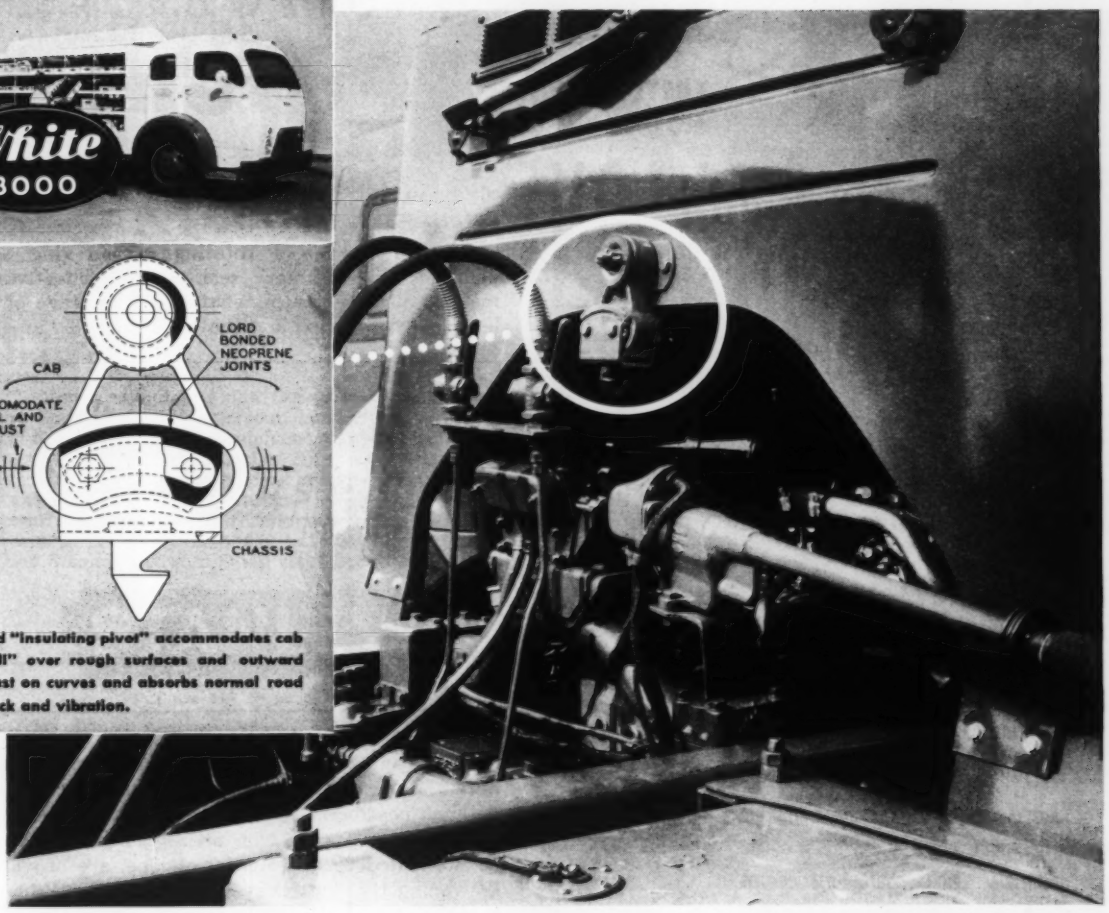
Brazing Machine: No. 20-2 Y-B multiflame brazing machine is used for brazing, soft-soldering, tempering, annealing and hardening. Operating on manufactured, natural or LP gas, it is 60 in. long, 24 in. wide and 34 in. high. Materials move through a heating zone that can be adjusted to accept materials up to 10 in. wide and to 30 in. high. Burner manifolds can be adjusted to allow angling flames properly for complex joinings. Rotating work tables can be added to conveyor belt to revolve work within the heating zone. *Youngberg Brothers, Meriden, Conn.*

Marking Machine: MM bar stock marker premarks steel, brass or aluminum bar stock before loading in automatic screw machines. It marks one side or opposite sides of round or hexagonal stock from ⅜ to 3 in. simultaneously. Bars are fed into the machine between driven rolls and are ejected with the mark indented. *Marking Machine Co., Battle Creek, Mich.*





Lord "insulating pivot" accommodates cab "roll" over rough surfaces and outward thrust on curves and absorbs normal road shock and vibration.



LORD "insulating pivot" contributes to smooth ride of WHITE tilt cab

The unique power-lift cab feature of White 3000 Series Trucks required a connecting device to anchor the rear of the cab to the vehicle frame. Such a device must combine high strength with resiliency to provide smooth, noiseless riding.

White called on LORD Vibration Control Engineers to tackle the problem. LORD's solution was an "insulating pivot"—a rugged bonded rubber mounting which absorbs road noise and cab motion—and requires no maintenance.

As a result, White has used these LORD mountings for four years as standard equipment without a single failure reported. This LORD Mounting replaced an all-metal sliding link which was subject to excessive rattling, costly maintenance and frictional wear.

Wherever noise and vibration are a problem, LORD will design the most efficient solution as a service to you. For further information, call your nearest LORD Field Engineer or the Home Office, Erie, Pennsylvania.

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Circle 617 on page 19

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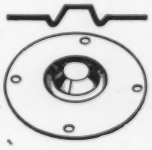

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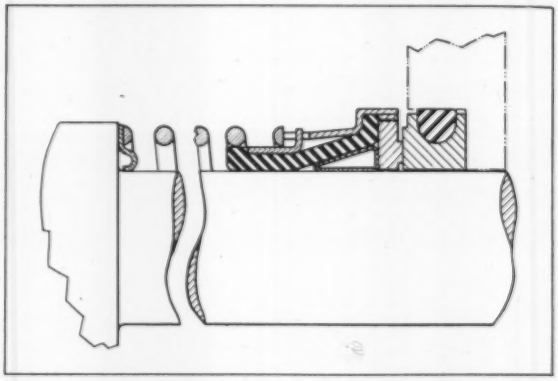
Circle 618 on page 19

NOTEWORTHY Patents

Rotating-Shaft Seal

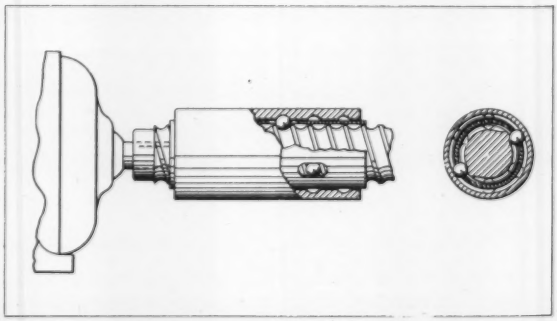
Contact between a rotating carbon ring and a polished-iron stationary seat provides effective sealing action in a rotating-shaft seal. Leakage of fluid between carbon ring and shaft is blocked by an elastic



sleeve, which is backed by a cylindrical metallic shell. Spring loading of shell, sleeve and carbon ring permits seal to accommodate end-play movement of shaft without possibility of leakage. Heat dissipation and squareness of carbon-iron sealing surfaces, which can be lubricated by an integral oil line, are provided by bottoming the stationary seal member in the housing counterbore. *Patent* 2,752,176 *assigned to Carrier Corp. by Robert W. Ayling.*

Ball-Bearing Screw

Rotational motion of a shaft is efficiently converted to linear motion by a ball-bearing screw device. Ball bearings, retained in elongated slots in a cylindrical sheet-metal cage, engage helical grooves



on the screw and parallel, circumferential grooves in the nut. For a given rotational speed, axial speed of the nut is determined by the diameter of the balls

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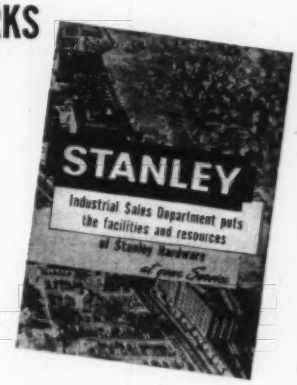

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STANLEY

Circle 619 on page 19

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RELIEF VALVES . . . in-line and pop-off design. Sizes ⅛" through 1" pipe size. Relief pressure from ½ to 1000 PSI. Brass, carbon steel, aluminum.

SHUT-OFF VALVES . . . handle and toggle operated. Sizes ¼" female pipe or ⅜" female tube. Operating pressures to 3000 PSI. Stainless steel.

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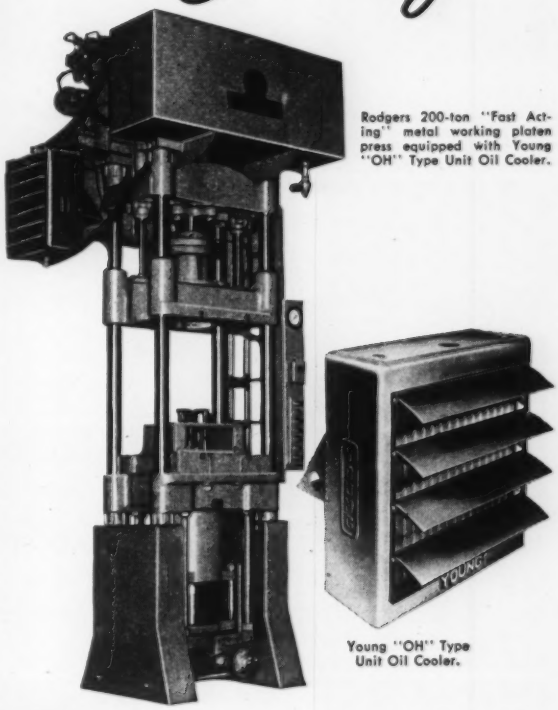
Circle 620 on page 19

200-ton platen presses depend on

Young Cooling



Rodgers 200-ton "Fast Acting" metal working platen press equipped with Young "OH" Type Unit Oil Cooler.

Young "OH" Type Unit Oil Cooler.

Young Unit Oil Coolers cool hydraulic oil for metal forming and drawing presses

Rodgers Hydraulic, Inc., specifies Young "OH" Unit Oil Coolers for its 200-ton platen presses. The Young units cool the hydraulic oil and transform the waste heat into useable heat for space heating. Patented Turbulators break up hydraulic fluid flow, creating a wiping action which increases heat transfer efficiency 100%.

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Circle 621 on page 19

ROCKFORD

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"MORLIFE clutch going strong after 1695 hours, working in sand."

"MORLIFE clutches last 950 hours longer, without adjustment."

"MORLIFE clutch needs adjustment once a month, instead of daily."

"MORLIFE requires lighter handle pull and one tenth the adjustments."

New MORLIFE* CLUTCHES and CLUTCH PLATES Give-

MORE Clutch Life (400% MORE)
MORE Torque Capacity (100% MORE)
MORE Heat Resistance (50% MORE)

These *new* ROCKFORD Clutches and Clutch Plates have been developed by ROCKFORD Clutch Engineers to take full advantage of recently discovered facing material. Actual field tests on heavy duty equipment have resulted in adoption of MORLIFE clutches by builders of tractors, earth movers, graders, shovels, cranes, trucks, oil field equipment and power units. For information how these *new* Rockford MORLIFE Clutches will improve the operation and increase on-the-job hours of heavy duty machines, write Department E.

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CLUTCHES

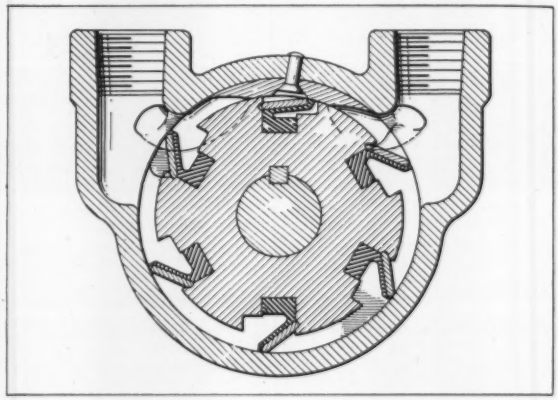
Circle 622 on page 19

Noteworthy Patents

and the pitch of the lead screw. An alternate design of the actuator allows the nut to freewheel when it reaches a predetermined axial limit. *Patent* 2,739,491 *assigned to Eaton Mfg. Co. by Robert C. Russell.*

Hinged-Vane Pump

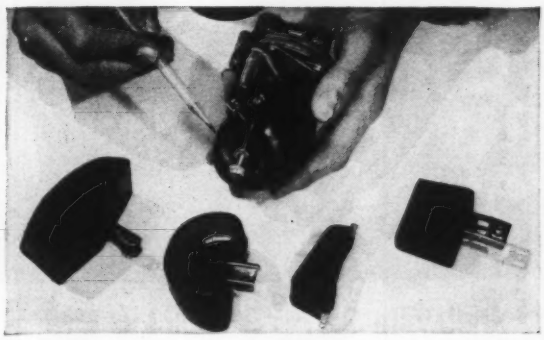
Fluid pressures exceeding 1000 psi are developed by a hinged-vane pump, which can also be used as a hydraulic motor. Pivoting flexible vanes, fabricated of rubber or synthetic material, retract into grooves



in the impeller face when their outer edges strike a reduced-radius ramp that is integral with the pump housing. Deformation of the vanes under high pressures is prevented by metallic backing plates bonded to the low-pressure side of the vanes. Since the pump operates without metal-to-metal contact, it is suitable for service in abrasive fluids. During pumping action of the configuration shown, the right-hand port acts as the inlet and rotation is clockwise. *Patent* 2,753,-809 *assigned to Jabsco Pump Co. by Marion A. Garrison.*

Composite bearing material consists of a layer of aluminum bonded to a nickel or cobalt-plated steel strip. Material can be bent or formed into various shapes without destroying the bond between the aluminum bearing surface and the ferrous backing strip. *Patent* 2,752,667 *assigned to Clevite Corp. by Ralph A. Schaefer, Joseph F. Cerness and Wilbert H. Morrison.*

Magnetostrictive strain gage, consisting of a thin, flat core strip and an integral bridge-leg winding, is suited for a variety of strain measurements. Permeability of core material varies with the applied strain, changing the inductance of the surrounding coil and giving a bridge signal proportional to the strain. *Patent* 2,749,746 *assigned to General Electric Co. by James H. Wright.*



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Better than cork! Lighter, can be used in higher temperatures. Parker sealed-cell rubber floats need no protective coating, are resistant to fungus. Won't become waterlogged. Maintain stable weight and volume.

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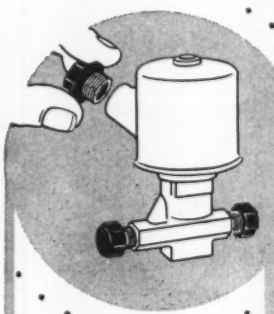
Parker
Hydraulic and fluid system components

Circle 623 on page 19



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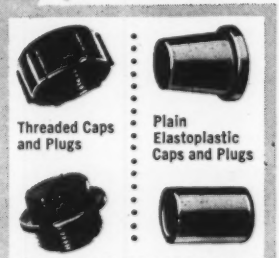

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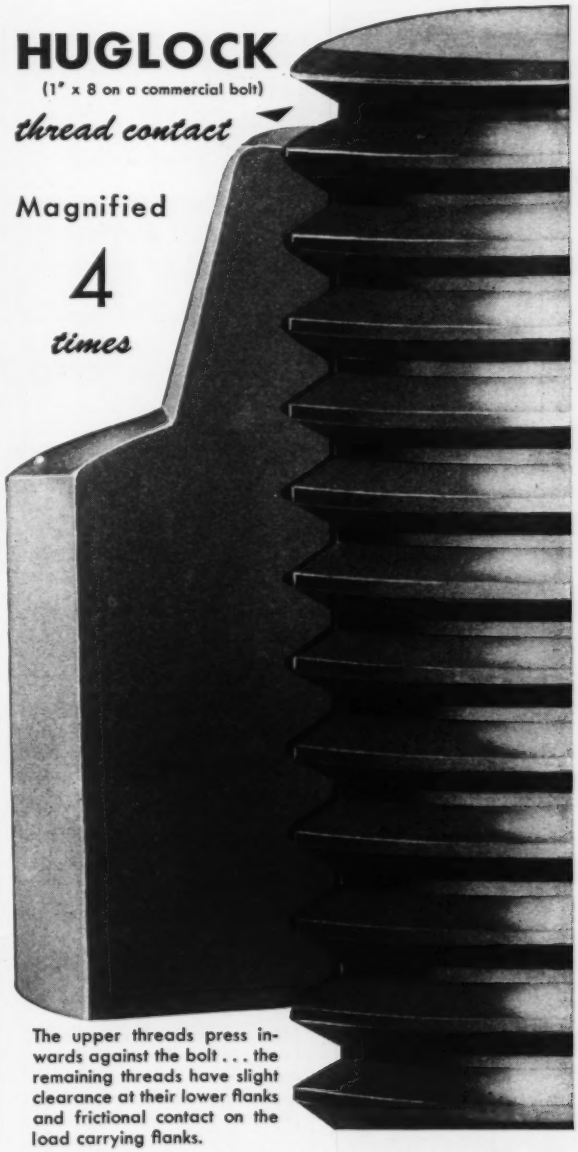
(1" x 8 on a commercial bolt)

thread contact

Magnified

4

times



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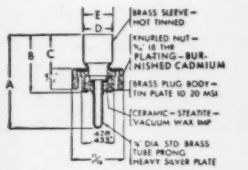
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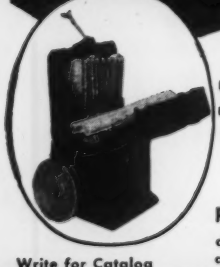

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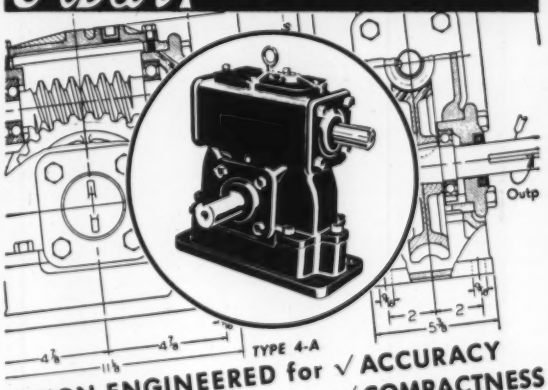

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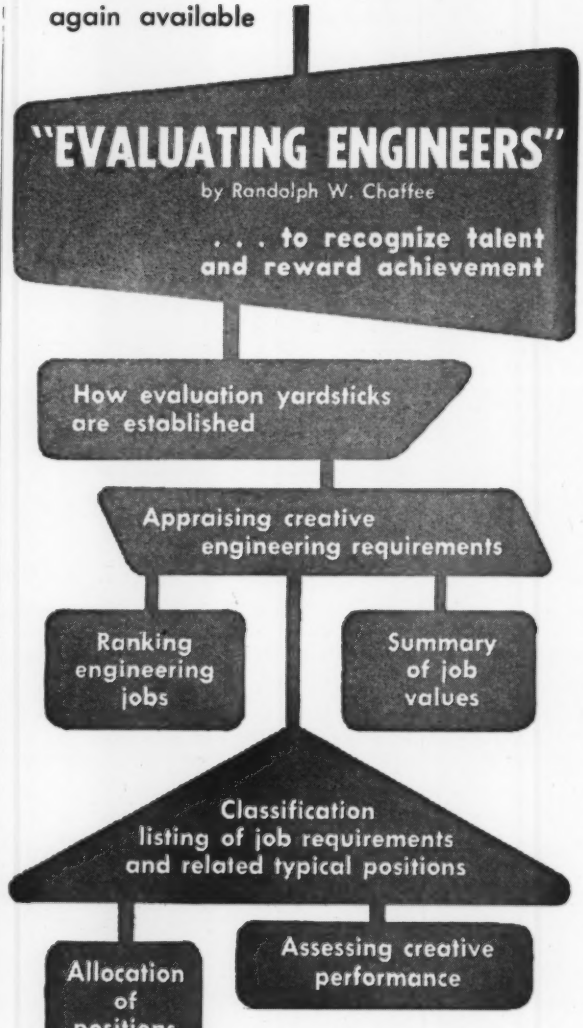
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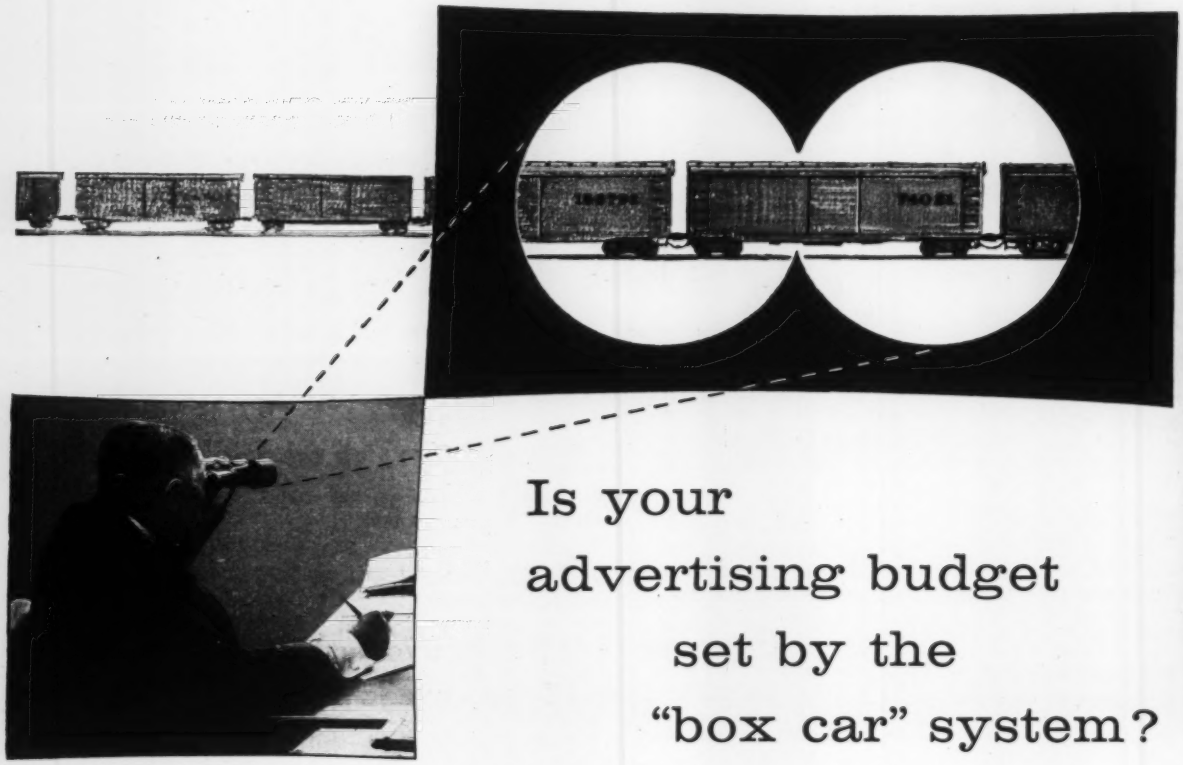

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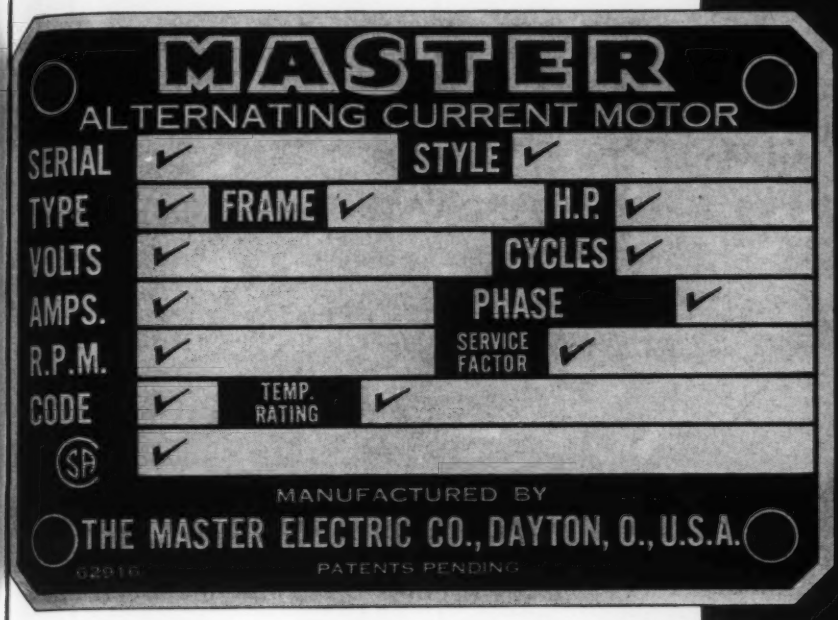

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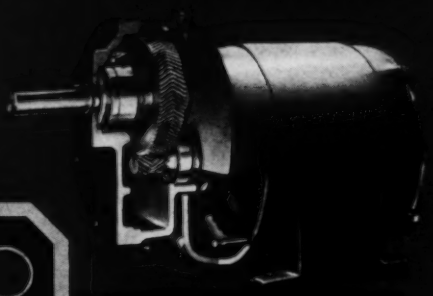
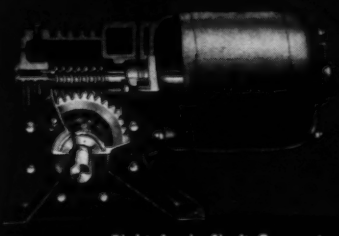


Parallel Shaft Gearmotors



Right-Angle Shaft Gearmotors

Unibrake Motors

Speedrangers

Standard Motors— ⅛ to 400 H.P.

Circle 502 on page 19